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ADVERTISING RATES GIVEN ON APPLICATION.

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WASHINGTON MEETING AMERICAN ELECTROCHEMICAL SOCIETY.

In our last issue we predicted that the Washington Meeting of the American Electrochemical Society would be the most enjoyable and the most numerously attended gathering of this vigorous and active society. Our prediction has turned out to be only half true. The meeting was certainly highly profitable and enjoyable, but in spite of the attractions of Washington in springtime, and in spite of an excellent programme arranged by the local committees, the attendance did not nearly come up to expectations. There is, however, nothing discouraging in this fact. Most of our flourishing national engineering societies have gone through the same experience; they have first held more than one general meeting a year, but have finally concluded that this is bad policy. To hold one general meeting, besides frequent local meetings, is now almost uniform practice. While not ideal, this arrangement takes at least the practical situation into account. The United States is a large country, and an engineering society has members in all its parts, and for a great many of the members the time and expense to be incurred in traveling to a distant place of meeting, make it desirable that the work of the society should be concentrated in one annual meeting. Then, everyone who wants to meet his professional co-workers once a year will attend this meeeting. With two meetings, one has the choice and some will attend the first, some the second meeting, and the principal object of a general meeting to bring all together will be defeated.

On the other hand, it cannot be denied that the American Electrochemical Society has held and holds a unique position among the other national societies. Its first meeting in Philadelphia in April, 1902, set a standard which has been fully sustained in its later career; with respect to attendance and quality of the professional proceedings, no meeting of the American Electrochemical Society so far held needs to fear comparison with its older and larger sister societies. But above all, it was the spirit of youth, of aggressive youth, which has characterized the work of this society. The true *esprit de corps* which now unites the electrochemists and electrometallurgists of this country and binds together engineers and scientists, is one of the most splendid achievements of the work of the society, and the spirit of good fellowship made every one of its meetings memorable. The Washington meeting was no exception.

And after all is said for one versus two general meetings a year, we must not forget that the present year is an exceptional one, on account of the St. Louis Exposition and the Inter-

national Electrical Congress and Chemical Congress, to be held in connection with it. The Electrochemical Society will hold its next meeting during the week of the Electrical Congress, and there is no doubt that many of its members are sparing their energies for this purpose, since they will have there an opportunity to impress their ideas on a wider and more general public. Everyone of our electrochemists and electrometallurgists is a pioneer, and to accomplish new results he has to break into the ranks of chemists, metallurgists and electricians. The Electrical Congress offers such an opportunity; and in future it might be worth while to try and arrange general meetings of the American Electrochemical Society simultaneously, and at the same place, with one of its sister societies, the American Chemical Society, the American Institute of Mining Engineers, and the American Institute of Electrical Engineers.

The professional programme of the Washington meeting was suggestive in this respect. While all the papers were electrochemical in character, at least in some respect, yet the majority of them would have appealed to a much larger field than merely electrochemists. Every electrical engineer should read with interest the papers of Profs. Carhart and Hulett, Dr. Wolff, Dr. Weedon and Mr. Zimmerman. Messrs. Carhart and Hulett on one side, and Dr. Wolff on the other side, worked out, independently of one another, a method of producing pure mercurous sulphate by electrolysis, for use in standard cells. The accuracy obtained in the tests is astonishing, and is far greater than has ever been reached before. There seems little doubt that the Weston cell will become the general working standard of e. m. f. Dr. Weedon's paper is suggestive as to the intimate relation which exists between the problems of the lighting engineer and those of the electrochemist. Dr. Weedon's paper gives a large amount of very interesting information on various details of the mechanism of flame arcs, but on the other hand, it also emphasizes how little we still know on electric discharges through gases in comparison with our knowledge of the conduction of the current through an electrolyte. We have for gases no such general law as Faraday's law in electrolytes. Dr. Weedon's results are conclusive in this respect. Of course, we have the electron theory, but it is still in the first stage of its development, although it fairly promises to bring finally all electrical engineering and all chemistry into the realm of electrochemistry. Mr. Zimmerman's results with the aluminium electrolytic condenser appear to show that this apparatus could be used to advantage—perhaps not for purposes of measurements requiring a high accuracy—yet for various general purposes of alternating-current engineering.

Some of the most interesting technical papers which were presented related to metallurgy, which is apparently one of the most promising fields at present for electrochemical endeavor. Electrolytic methods have been chiefly successful in the refining of metals, and from the important paper of Prof. Burgess and Mr. Hambuechen we see that iron is to be added to the list of metals which can be refined electrolytically at a cost that is not prohibitive; the main problem is now to find commercial uses for pure iron. Mr. Addicks' paper on the economic balance in copper refining emphasizes that electrolytic refining of copper—one of the simplest electrochemical problems in the laboratory—becomes an enormously complicated problem from the financial point of view if worked on a large scale. The great number of variables on which the results depend, explains why the details of operation, like current density, etc., must change from one refinery to the other, if the financial efficiency shall be a maximum. Mr. Johnson's paper on the reduction temperature of zinc oxide was an interesting example of the applications of laboratory methods of measurements to a problem of technical metallurgy; there can be no doubt that work of this kind, carefully carried out in the research laboratories of our large metallurgical plants, will indirectly bring about important advances in the operation of metallurgical processes. Mr. Sjöstedt's interesting paper was an account of a special phase of the electrometallurgical work which has been going on in the past years at Sault Ste. Marie.

The other papers presented at the meeting either referred to electrochemical theory or experimental work. Mr. Mott gave the results of his valuable experimental determinations of the single potentials of the halogen elements; while it is questionable whether his values really represent "absolute potentials," yet this is of small account, since in practice we always have to do with differences of potentials, and any constant additive term which might be added to Mr. Mott's values would drop out of the difference. Dr. Adams—the "father of nickel plating"—and Mr. MacNutt described some observations made in the use of the copper voltameter. Mr. C. F. Carrier's paper was a contribution to the increasing literature on the electrolytic preparation of white lead, while Mr. Davis described some peculiar observations on osmotic pressure and alternating currents which should invite further investigation. Dr. Richards gave a generalization of Thomson's rule, so as to apply to the case that several electrochemical reactions are simultaneously going on; like Thomson's rule, it is purposely based on the simplifying assumption that chemical and electrical energy are the only forms of energy to be taken into account, so that a term of correction due to the role that heat plays in electrochemical phenomena should be applied. But as Thomson's rule is found useful in general practice, Dr. Richards' method of calculation may be considered to be correct to the same extent. In a paper on molecular conductivity, Mr. Reed made a vehement attack upon the dissociation theory, while Dr. Parsons' paper was an able defense of the same theory against criticisms based on the energy principle. Quite a number of the papers had been printed in advance, but it would be well in future to send out advance copies of the papers to all members, several days before a meeting, since this would enhance the value of the discussions.

Dr. Richards' presidential address was an inspiring review of the continuous advance of electrochemistry, full of suggestions as to future developments. With this able address, Dr. Richards retired from the office as president, having been privileged for two years to lead the society to successes far beyond the first fondest hopes of those who conceived its formation. Together with him, Mr. C. J. Reed, the first secretary, retired from his old office, in which he had served the society with

such unselfish devotion and untiring energy. What its first president and secretary have done for the society and thus, indirectly, for the interests of electrochemistry in the United States, will never be forgotten.

THE CHEMICAL ENGINEER.

In this issue we give an extended report of a very suggestive paper by Mr. Herreshoff on the training of the chemical engineer, and of the very animated discussion which followed this paper. The subject is of the highest importance, since the proper training of the young men of to-day will determine not only their own future, but that of the chemical industries of this country. The subject was exhaustively discussed from all points of view, and the differences of opinion were mainly as to the methods of training. With respect to the fundamental point there appeared to be unanimity of opinion; that is, that what is badly needed for our chemical industries are men who are not chemists pure and simple, but who have a good knowledge of physics and mathematics, and a thorough training in engineering. We may add that the rapid advances which have been made in electrochemical industries in recent years were accomplished by just such men, and would have been impossible otherwise.

THE EDISON NICKEL-IRON BATTERY.

On April 28 Mr. Robert A. Fliess, the superintendent of the testing department of the Edison Storage Battery Co., delivered a lecture before the New York Electrical Society on the development of the nickel-iron storage cell. It was especially interesting, for the reason that, since Dr. Kennelly's paper of three years ago, in which this latest invention of Mr. Edison was first announced, Mr. Fliess' statements represented the first authoritative information given out by the manufacturers themselves on this much-discussed battery. With the aid of a great many lantern slides, Mr. Fliess showed the mechanical development of the battery from the beginning up to its present form, and showed curves representing the advances made during this development. For instance, discharge curves were given, showing the ampere-hours obtained per gram of active nickel material and per gram of active iron material. These curves showed that the ampere-hour efficiency of the active material had been doubled since the beginning of the experiments. Mr. Fliess also gave the characteristic curves of the three types, C, D, E, of commercial cells, so far made; type C has certain advantages over D, while D has other advantages over C, and in E the advantages of the two former types are combined. In the latest type the watt-hour capacity, which was given by Dr. Kennelly in his paper, and which had been derived from experiments on somewhat like a test-tube scale, has exactly been reached again for commercial cells, namely, about 14 watt-hours per pound.

While Mr. Fliess thus gave very interesting data on the results accomplished by the gradual improvement of the cell, he did not state the methods by which these improvements had been accomplished. Concerning the relative advantages of the three types, C, D, E, it appeared as though in one of the two former types there was too much nickel and not enough iron, in the other too much iron and not enough nickel, while in the latest type the two active materials are exactly balanced. Concerning the enormous advances made in the utilization of the active materials, the question would be whether they were due to improved chemical or mechanical methods, or to both. Chemical purity is of the greatest importance to insure long life, and this depends on the absolute insolubility of the active materials in the electrolyte. On the other hand, the methods of packing the active materials in the little boxes more or less tightly and of mixing with some conducting material (like graphite) will evidently have a very great influence on the degree to which the active material is utilized. Mr. Fliess laid great stress on those points in which the nickel-iron cell appears to be superior to the lead cell—its light weight, its capability of being discharged at very high rates without losing capacity, its "fool-proofness," and its long life.

The discussion which followed may well be summed up in the remark of Mr. Blizard: "I see the lead cell is in the hands of its friends." The criticisms brought forward by various speakers were mainly that the nickel-iron cell is more bulky and more expensive than the lead cell; and Mr. Bijur asked a pertinent question when he requested to give an exact figure for the number of charges and discharges which an Edison cell will stand. It is, perhaps, still too early to give such a figure, since Mr. Fliess simply replied that, like wine, the Edison cell appears to improve with age. After all that has been said in the case of the Edison cell versus the lead cell, one may conclude that the day is far off, if it ever comes, when the alkaline accumulator will replace the lead cell for general work, but it is equally certain that the Edison battery has very great possibilities for future developments, and that it will surely have a large field of usefulness in special fields, in which the distinct advantages which it possesses are of importance.

THE COMBINATION OF A SOLVENT WITH THE IONS

In this issue we publish an abstract of a paper by Messrs. J. L. R. Morgan and C. W. Kanolt, which is very interesting since, by a method somewhat similar to Hittorf's determination of the transport numbers, the authors show conclusively that in certain solutions a combination of the solvent with the ions exists. By applying this result to a simple aqueous solution of a salt they also show that the discrepancies found between the electrolytic dissociation theory and the facts can be made to disappear. This is perfectly correct. It may be argued, however, that the results of the authors cannot be directly applied to the case of a simple solution of a salt in a solvent, since what they experimented with were rather solutions of a solution in another solvent. Nevertheless, the facts ascertained by the authors are very interesting. On the other hand, it would be extremely valuable to work out a method for determining decisively what the ions are in a simple solution. For instance, in a dilute aqueous solution of sodium chloride we assume the ions to be sodium and chlorine, but there exists no evidence which would prove that, for instance, combinations of the sodium or chlorine ions with water do not exist in the solution. What is mostly needed in this respect is experimental evidence, not theoretical speculation, and we trust such experimental evidence will soon be brought forward.

FARADAY SOCIETY MEETINGS.

An ordinary meeting of the Faraday Society was held on March 21 at the Institution of Electrical Engineers, London, Dr. O. J. Steinhart in the chair.

A paper by Dr. F M. Perkin and Mr. W. C. Prebble on the "Electrolytic Analysis of Gold" was read in abstract by Dr. Perkin. An abstract of this paper was already published in our April issue on page 159.

Thin-Film Electrolysis.

Mr. Charles R. Darling then read a paper on "Thin-Film Electrolysis, and a Proposed Application to Printing," which was illustrated by experiments. While investigating a process for letter press printing by electrolysis without the use of ink—an extension of Bain's well-known telegraphic printing—the author found that the final results of electrolysis, when the electrolyte forms only a thin film—often differ materially from those observed in an ordinary cell. In these experiments a carbon or metal plate (it was immaterial which), formed the anode; on this was placed an impression pad, consisting of some sheets of moist blotting-paper; upon this was the trial sheet, carrying the electrolyte film, and on this the cathode type or coin.

Voltages from 6 to 200 were employed. To obtain a clear image of the type a certain minimum strength of solution is requisite. The first experiments were made with saline solutions; silver nitrate gave a clear, permanent black image of the type, but the paper, of course, darkens on exposure; copper sulphate and nitrate yielded images that faded after a time; the same unexpected result occurred with lead, mercury salts, and bismuth. The best images were obtained with manganese salts. These consisting, as they did, of the oxides or hydrates, were quite permanent; all purely metallic deposits, excepting silver, disappeared after a time. In the case of non-saline solutions the paper, which might consist of asbestos or pure Swedish filter-paper, soaked in distilled water, acquired the properties of an exposed photographic plate, and on treating with a silver salt and developer a perfect image of the cathode was obtained, even after a long interval. The latent images are not due to hydrogen peroxide, nor to metallic compounds, as they occur with carbon electrodes; but they reside in the surface of the paper in contact with or towards the cathode. The author ascribed them to a class of phenomena that have been investigated by Bose and termed "the response of inert matter to electrical stimuli," and thinks they are probably the result of some state of strain set up in the film by the current. As regards the fading of the metallic images, this may be simply due to recombination, although that explanation is not entirely satisfactory.

In the discussion which followed, Dr. H. Borns asked whether the author had treated his latent images with any solutions before developing. Mr. N. J. Blumen said that in some electrolytic printing that he had carried out they had used some organic solutions with good results. Mr. Fontana suggested that the latent images might be due to occluded hydrogen. Dr. Perkin thought this supposition could be tested by exposing the paper to an oxidizing agent. Mr. Bawtree asked whether it were possible to get rid of the latent images. If so, some light would be thrown on their cause. Mr. Prideaux asked whether the author had tried developing anode images where carbon formed the anode, so that no metal went into solution. Dr. Steinhart did not agree with the "strain" theory put forward by the author. All materials contain some trace of saline matter, and one is almost sure to get chlorine or some such substance given off on electrolysis. Mr. Darling, in reply to Mr. Bluman's remarks, said that organic substances eventually discolored the paper. He did not think hydrogen the cause of the latent images; certainly hydrogen peroxide does not destroy the image.

The ordinary April meeting of the Faraday Society was held on Wednesday, April 13, Mr. James Swinburne in the chair.

Alloys of Copper and Arsenic.

Mr. Arthur J. Hiorns read an abstract of his paper on "Alloys of Copper and Arsenic." The object of his investigations was to ascertain the exact relation between copper and arsenic in binary alloys, and the limit of proportion of arsenic that can be retained in copper in the cold solid state.

The addition of arsenic lowers the melting-point of copper uniformly down to about 14 per cent, when a steep fall in the freezing-point curve occurs, reaching its lowest point at 685° C. This alloy contains 19.2 per cent of arsenic, which corresponds to the formula Cu_5As. The alloy, with 22 per cent of arsenic freezes at 708°, and the freezing point gradually rises until the alloy with 28.34 per cent is reached at 747°; this is Cu_3As. At 810°, Cu_3As_2 freezes, containing 32.2 per cent of arsenic. Beyond this point the freezing point gradually falls again, until a minimum is reached at the alloy with about 35 per cent of arsenic. The curve then rises to another summit at 740°, corresponding to Cu_2As, with 37.24 per cent of arsenic. From this position the curve decends to 702°, with the alloy containing 41 per cent of arsenic; this is nearly the practical limit of the direct combination of copper and arsenic.

The top surfaces of many of the alloys were photographed. The types of pattern visible on the etched surface depend upon the position of the freezing point on the curve. For alloys whose freezing point is on or near the summit of a curve, the whole of the section is composed of one substance, generally made up of crystal grains having fine boundaries. When, by addition of copper or arsenic a summit of a curve is left, the lines between the crystal grains widen and become filled with a network of matter differing from that of the crystals and generally showing a more or less striated appearance, so characteristic of eutectics. As the bottom of a curve leading from a summit is reached the eutectic occupies the whole surface. It is noticeable that the alloy of minimum fusion of copper-arsenic alloys has an extremely fine striated structure. Any deviation in composition from the eutectic proportion causes the breaking up of this striated pattern, and grains of one of the constituents appear in the eutectic matrix.

A microscopic examination was also made of polished sections of the various alloys. These, when viewed in daylight, are all copper-colored in those with little arsenic, and gradually get paler as the arsenic is increased. When the alloy with 19.2 per cent is reached, the surface appears of a pale blue color, and this is continued up to Cu_3As, containing 28.34 per cent, which is of a deeper blue color. The alloys between 19.2 and 28.3 per cent have a paler blue tint, because the blue constituent is associated with a constituent richer in copper, forming a eutectic mixture. The alloy with 30.0 per cent is of a light purple color, and when Cu_3As_2 is reached, containing 32.2 per cent, a full reddish purple is obtained. This purple color maintains up to the limit of these experiments with 45 per cent of arsenic, but gets gradually paler. The paper was concluded by a detailed description of the various alloys fully illustrated by excellent photomicrographs.

Mr. E. G. P. Bousfield then read two papers on "Experiments with a New Primary Cell," and on the "Determination of the Percentage of Ozone in Gases." Both papers are abstracted in the Synopsis of our present issue. In the discussion of the paper on the Bousfield primary battery, Mr. W. R. Cooper referred to the disadvantages of both nitric acid and caustic soda as electrolytes; the high e. m. f. of the cell was only apparent, because it rapidly fell to a working value of 1.8 or 1.9; he would like to have seen comparative tests made, say with a bichromate cell. Mr. J. Swinburne mentioned a suggestion made by Dr. Swan, that the cell would be improved if it were converted into a three-fluid cell, with a neutral electrolyte (*e. g.* $NaNO_3$) in the mid-compartment.

Edison Storage Battery.—Mr. R. A. Fliess recently delivered an interesting address on this battery before the New York Electrical Society. We comment on it in an editorial.

THE CHEMICAL ENGINEER.

The very important and timely subject of the training of the chemical engineer was discussed in a most interesting manner by Mr. J. B. F. Herreshoff, in a paper recently read before the New York Section of the American Chemical Society. This paper elicited an animated and prolonged discussion in which industrial chemists and university professors equally participated. In the following we give an abstract of the paper and the discussion. The complete paper and discussion may be found in *Science*, April 8.

Mr. Herreshoff pointed out that in 1850 the value of manufactured products in the United States was $1,000,000,000, and in 1900 it was $13,000,000,000 (while the value of unmanufactured agricultural products was estimated at $4,000,000,000). In bringing about this enormous increase, chemistry, assisted by engineering, has played a most important part. Our iron and steel industries, our whole field of metallurgy, and, indeed, the majority of the great industries would have remained in a crude, dormant state, had it not been for the important work of the chemist and his more practical brother, the technical chemist. While it is true that the number of chemists engaged in active work in this country has increased in the last thirty years in a proportion far beyond that of the increase in the value of manufactured products, yet we are still backward in the employment of chemists when we compare our position with that of Germany. Concerning this point Mr. Herreshoff gave some interesting data.

In this country there are numerous examples where the technical chemists have immensely improved manufacturing conditions, either by lowering costs or by producing a higher quality of product. There is still much room for improvement, and Mr. Herreshoff expressed the opinion that there is hardly a plant in the country turning out products requiring chemical skill where marked improvements could not be made by the very best work of technical chemists in effecting changes that would reduce the cost of labor and fuel in recoveries from waste products or by producing better material.

During his long experience in connection with chemical manufacturing and metallurgical work, Mr. Herreshoff has found that the majority of chemists who are employed as analysts, technical chemists and as works or department managers, have perfected themselves in chemistry alone, and seem to have neglected the importance of physics and engineering. If a chemist wishes to achieve the greatest success in industrial work he should not undertake the problem at all, unless he has made up his mind to perfect his mathematics and become thoroughly familiar with physics as well as mechanical engineering. It seems a great mistake that the term technical chemist has been used in connection with chemists who are obliged to apply chemistry in manufacturing processes. We should speak rather of chemical engineers, as we speak of metallurgical engineers, mining engineers, electrical engineers.

present. Our colleges should consider this matter more seriously than ever, and do their best to make the course in chemical engineering as complete and perfect, in every way, as possible. Chemical engineering necessitates a greater variety of engineering than all the other branches of engineering combined. In designing the apparatus that is employed in conducting the endless variety of chemical and metallurgical processes, every known metal and alloy is used in every conceivable variety or form. All kinds of brick are used, acid, basic, neutral and vitreous, glass, all sorts of pottery-ware, porcelain, stone, rubber, coke, asphalt, wood, cements, etc., and these in every combination and form which the best chemical engineering skill can devise to improve old methods and properly conduct new processes. In order to select the best material with which to carry on difficult prob-

When noticing the enormous field of manufacturing in this country, one cannot help feeling that a study of mechanical engineering should be very much more general than at lems, the chemical engineer must have a wide knowledge of the action of acids, alkalies and chemicals under all conditions of solution and heat, upon all known substances which could be employed to carry on the processes. Generally in new problems, carefully conducted investigations have to be made on a small scale, to show conclusively the best substances to be used.

In the designing and construction of plants and apparatus, the chemical engineer has not only to select the most suitable material, but he must so carefully study the function of every detail of the apparatus to be used, that each part will successfully meet the full requirements. Each and every part must be proportioned to what it has to do; everything must be proportionately strong and large enough for the purpose, always avoiding unnecessary extremes in order to curtail the first cost of the plant. The desired end must be met in the simplest possible manner, and the devices so arranged that while operating they will be so nearly automatic that good results will be achieved with the least possible labor. The plants must be so designed that the greatest yields will be obtained and the finest products turned out.

But after all this is done the chemical engineer will not be thoroughly skillful and up to date unless he designs every part of the apparatus so that it will last the longest possible time. Everything must be arranged so that when repairs are required they can be conducted with the least expense.

For the successful operating, maintaining and improving the condition of plants where chemical skill is employed, the manager or superintendent and his assistants must be trained not merely in chemistry, but in mechanical engineering as well. Training in business and departmental management is also highly desirable. However perfectly a plant and its apparatus may be designed and erected, it will not necessarily give successful results unless every machine, furnace, still, condenser, tower, etc., is operated under the management of a man who is fully conversant with the function of every detail of the apparatus. If the superintendent is properly educated in chemical engineering and has had a proper training as an assistant superintendent or practical investigator, and especially if he has a natural fondness for machinery and mechanics, then success will crown all his work. Whenever there is a difficulty—something breaks down and bad results follow—then he will at once clearly define the reason for the trouble and take the proper steps in completely correcting the evil. He gives true reasons for everything that is done in the various departments of the plant. He sees much going on that is unreasonable, and step by step he brings the unsatisfactory work up to a higher and higher standard. His assistants are chemical engineers, and he inspires great confidence and interest in them by a course of training that causes them to think and reason from every standpoint, so that before taking action, everything having an important bearing on the chemical, physical, engineering, business and labor sides of the problem in hand is most carefully considered.

The chemists in the analytical laboratory are not always college graduates, as most of the work is of a routine nature, requiring great skill in manipulation, but not necessarily an extensive knowledge of chemistry. These men when confined to this work have no opportunity to employ engineering skill except in perfecting the apparatus used in making chemical analysis. It is of the utmost importance that their analyses are accurate and quickly performed. It is the custom in all well managed industrial laboratories to investigate frequently the analytical methods used. For this reason the most desirable analytical methods are often found in industrial laboratories and the colleges should endeavor to keep abreast with the best practice operated there. There is no reason why the training of analysts in large laboratories should not be of the highest order.

The future success of any well-established industrial institution of a chemical nature is in grave peril if it does not have

an investigation or research department. The manager of this department must be by education a chemical engineer. He should have had large experience as a practical business manager of plants, and a direct acquaintance in the designing, reconstruction and repairs of the same. This department must have a properly equipped research laboratory. The head of this research laboratory must be possessed of very high attainments as a chemist and physicist, with a fair knowledge of mechanical engineering.

The great majority of chemists in this country are engaged in practical work where they need engineering assistance, and in such cases the chemist who is not an engineer would have to consult the engineer for practical advice, and the engineer seeks chemical assistance from the chemist, and, without a knowledge of chemistry, obtains but little satisfaction. A complete understanding of the various problems must come from a brain that can think in both chemistry and engineering. The dignity and fame of chemistry will not be injured by joining in close union with engineering. Indeed, the real value and glory of chemistry comes from its application to useful products that add comfort and happiness to the human race. These applications cannot be carried on without the aid of engineering. Applied chemistry would be greatly benefited in this country if the colleges would come in closer touch with the manufacturer.

In the discussion Dr. T. J. Parker (General Chemical Co.) remarked that if the application of chemistry to manufacturing processes is desired, it is certainly necessary for the young chemical engineer to have a knowledge of mechanics or engineering as well as chemistry, in order to apply it efficiently in our factories. The opening for the industrial chemist in the next five or ten years seems simply phenomenal.

Mr. M. C. Whitaker (Welsbach Light Co.) remarked that when the processes connected with manufacturing industries are referred to the chemist for improvement, he repairs to his laboratory and goes through some very serious painstaking work. But this work is not appreciated by the superintendent because he is not a chemist. What the superintendent asks for is actual merchantable results. The chemist is generally not a man who is capable of transmitting from a laboratory to a factory the ideas which he has developed. To change this situation, he should have a knowledge of electrical and mechanical engineering, and he should have that knowledge of getting along with people so that after he has prepared his plans and laid them out, he can get help to bring about those results which he desires. He must not only develop new ideas, but he must have the knowledge to put them into practice. Such men, instead of being assistants in our manufacturing industries, will be leaders.

Dr. William McMurtrie agreed with the opinions expressed, but emphasized that the training of the technical chemist, as well as that of every technical and professional man, should begin much earlier than the entrance to the technical school. It should begin even in the earlier grades of the primary school. Here the idea should be abandoned that the young minds are too immature for study and systematic work, that the children need to be amused rather than seriously educated; that they must be trained by kindergarten methods in lines which later must be traversed again in the serious struggle for education. Thus precious time is lost at the age when the mind is most pliable and receptive. It would be far better to return to the old-fashion methods of the three R's—reading, writing and arithmetic.

Prof. Edward Hart (Lafayette College, Easton, Pa.) thought that we must in the first place reconcile ourselves to the idea of doing the best we can in four years. It is necessary to first teach the science of chemistry thoroughly and well, so far it is possible, and then to teach engineering, because the chemical manufacturer is an artisan. He must be an artisan to a certain extent. In the four years course it will not be possible to get into a man more than the elements of engineering, but if this is done well the product will be quite different from that turned out at the present time.

Prof. W. A. Noyes (Rose Polytechnic Institute, Terre Haute, Ind.) emphasized that the basis of the training for the technical chemist and for the chemist of all kinds must be a thorough training in analytical chemistry. This training has now become inferior to what it was a few years ago. Industrial chemistry can be put into a four years course only to a comparatively small extent. It is manifestly impossible to train every young man for that particular field into which he will later go.

Prof. C. F. Chandler (Columbia University) said that the difficulty is that our students, entering a college for four years, never know what particular branch of chemistry they intend to pursue in after-life. They are, therefore, treated all substantially alike, and get all substantially the same chemical education. But our young students apparently expect the instructors to do their work. "When I was a student I went into Wöhler's laboratory. He gave us a lecture every morning, and we were expected to attend that lecture and make the most of it. Then we went into the laboratory. He handed me a piece of triphyline, and said: 'I want you to get some lithia out of that.' He did not give me an hour's lecture and tell me how to make lithia and have me write it down. He gave me a piece of the mineral, and I had to hustle and find the solution of the problem myself. He said: 'You have to make some lithia out of that, and after you have made up your mind, come to me and I will look over your proposition and see whether it is right.' That was the way chemistry was taught in Wöhler's laboratory. There was a small number of students, and that method of instruction was carried out." Now students expect that they are told every step which they have to make in an analysis. The speaker did not think that instruction in engineering can be given in a four year's chemical course, although it would be highly desirable.

Prof. A. A. Noyes (Massachusetts Institute, Boston) thought that institutions could do a great deal of good by laying out a definite course of fifth-year work, leading to some higher degree. There is a difference between a chemical engineer and an engineering chemist. What is wanted of a factory chemist in this country is rather the power of solving new problems and of making improvements in processes—a power to be acquired far more by a good chemical training, which should include a large proportion of research and other work, requiring independent thinking, than by engineering training. If instruction in mechanical engineering is to be given in chemical courses, either the time devoted to analytical chemistry or to modern languages must be reduced.

Prof. H. P. Talbot (Massachusetts Institute, Boston) thought that analytical chemistry is some times taught in a too abstract way, while it is possible to connect analytical chemistry in the mind of the student more closely with the scientific or industrial problems to which it is to be applied, and in this way stimulate his interests and develop his ingenuity.

Dr. Wm. Jay Schieffelin pointed out that most of the industrial processes are elaborations or applications of methods used in analysis; therefore, the technical chemist should know the methods. It is very hard to-day to get a man who is a good analyst, upon whose analysis one can entirely rely. If he must make an analysis which he has not made before, he takes a book of selected methods and goes through it, but his results are not satisfactory. The speaker thought that knowledge of the German language is immensely important, because the German works, Beilstein and Dammer, are to-day the chemists' bibles, and contain nearly everything on organic and inorganic chemistry which he wants to learn about, and we haven't their parallel in the English language.

Dr. Hugo Schweitzer expressed himself absolutely against

the introduction of chemical engineering in the education of chemists, and wants to restrict the same to pure chemistry. It is the manufacturer who asks that we should be both chemists and chemical engineers. The speaker thought that it is the employers who need education. What they now do is to engage a chemist, to pay him a generous salary and to think he ought to be a chemical engineer besides. What the manufacturers ought to do is: they should take the graduates from the university as they are educated in pure chemistry and educate them at their works at their expense during one or perhaps two years to become technical chemists and chemical engineers.

Mr. Maximilian Toch suggested that the colleges invite men to lecture who have been successful in manufacturing industries, and who naturally can impart knowledge to students such as a professor is not expected to have. The college laboratory is totally different from a factory.

Prof. M. T. Bogert (Columbia University) thought that the manufacturer really wants two kinds of chemists. First, what may be called technical directors, men who are trained more thoroughly on the mechanical side than on the chemical side, who understand the handling of both men and machinery, and who know in a general way the chemical processes to be carried out; and, secondly, scientifically educated chemists. The training of these two classes of chemists should be quite different. The man who is working in the laboratory, the man behind the gun, is the man who has accomplished results in Germany as well as in this country. Progress in Germany in technical chemistry has been due largely to the work in research laboratories by men who had no engineering training, and the speaker emphasized that it is only through the establishment of such research laboratories that the American chemist can hope to compete with the German chemist.

Mr. W. H. Nichols (President General Chemical Co.) said that the young man who goes to college to get his technical training should determine whether he is going to use it in the realm of pure research or whether he is going to be a chemical engineer. A college course is simply a foundation on which the further education is to be built in after life.

WASHINGTON MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The fifth general meeting of the American Electrochemical Society was held in Washington from April 7 to 9, and the professional proceedings as well as the social features of the convention were again an unqualified success, although the attendance was smaller than had been expected. The members and guests who registered numbered somewhat less than 100, an alphabetical list being given at the end of this report.

The lecture hall of the Columbian University had been placed at the disposal of the Society, and there three morning sessions were held, devoted to the reading and discussion of papers, while in a special evening session on April 7 the retiring president, Prof. J. W. Richards, delivered his address on the continuous advance of electrochemistry.

The first meeting was opened by a speech of hearty welcome by President C. W. Needham, of the Columbian University, who remarked that Washington is a sort of switchboard where one can make connection with every part of the country, and even of the world. He spoke of electrochemistry as being now in the front rank of the sciences and arts, and of its influence in saving labor and making life more worth living. President Richards thanked him for his inspiring words and for the hospitality extended. The secretary, Mr. C. J. Reed, then presented his annual report, in which he gave a statement of the membership and of the publication and distribution of the Transactions. During the last year 196 new members were elected, and the total membership is now somewhat near 700. The treasurer, Mr. P. G. Salom, could not attend the meeting on account of death in his family, and his report was read by Mr. Reed. It shows that the profit of the Society from the time of its first existence up to now amounts to $1,652.52. In addition the Society holds $250 for the Frenzel prize, which was offered for the best paper on the subject of rare metals. The president announced that this prize has not yet been competed for, and the offer is still open. Mr. Carl Hering moved that in future the secretary's and treasurer's reports should be printed in advance. This motion was carried. An amendment to the constitution was unanimously carried, according to which the president, vice-presidents and managers shall, after the expiration of the full term of office to which they were elected, be ineligible for immediate re-election.

The president announced that the board of directors has decided to hold the next general meeting during the week of the International Electrical Congress in St. Louis in September. Three official delegates of the Society to the Congress will be appointed by the board of directors. They will present special papers before the joint meeting of the Electrochemical Section of the Congress and the Electrochemical Society.

The result of the election of officers for the coming year was announced by the tellers during the session of Saturday. As evidence of the interest taken by the members in the Society it may be mentioned that 361 legal votes had been cast; that is somewhat more than 50 per cent of the total membership. Prof. Henry S. Carhart was elected president, Messrs C. J. Reed, E. G. Acheson and C. P. Burgess vice-presidents, Messrs. W. H. Walker, C. E. Acker and E. Weston managers. Mr. S. S. Sadtler was elected secretary, and Mr. G. P. Salom was re-elected treasurer. Prof. Burgess had been elected both for the offices of vice-president and manager, and accepted the former office.

The social features of the meeting were extremely enjoyable, and much credit is due to the untiring efforts of the local committees, with Col. Samuel Reber as chairman and Mr. Clinton Paul Townsend as secretary of the general committee, and Dr. N. M. Hopkins as the chairman of the entertaining committee, who, with the other Washington members of the Society, successfully endeavored to make everybody feel at home. The Cosmos Club, through its board of managers, extended the courtesies of the club to members of the Society, and Mr. E. J. Prindle courteously placed a room of his law office, including the services of a stenographer, at the disposal of the members of the Society.

On Thursday noon, the members of the Society were presented to President Roosevelt at the White House, to shake hands with the chief magistrate of our country. On the afternoon of the same day a complimentary excursion on a special "Seeing Washington" car to all parts of the city was greatly enjoyed, while attention was called by means of a megaphone to everything that could possibly be of interest. Since the weather was good and the parks of Washington appeared in the first green of the spring, this trip was greatly enjoyed.

On the afternoon of Thursday a visit was made to the Navy Yard, where the visitors had an opportunity to see the shrinking of a jacket tube of one of the largest modern guns. On the afternoon of Saturday visits were made by different

parties to the Bureau of Chemistry, the Bureau of Engraving and Printing, and an excursion, either by trolley or boat, to Mt. Vernon. The National Bureau of Standards was open for inspection on all days of the meeting.

On the evening of Thursday, immediately after Prof. Richards' presidential address, a complimentary smoker at Rauscher's was greatly enjoyed, a special feature of which was the drawing of cartoons with lightning rapidity by Mr. Clifford K. Berryman, of the staff of the *Washington Post*. While almost all his cartoons represented senators, congressmen and politicians of national fame, one was a highly amusing caricature of Dr. Wiley, and we regret that the confiscation of this cartoon by the object of the sketch prevents us from reproducing it here.

On the evening of Friday a subscription banquet was held at the Shoreham. Dr. Wiley was a most successful and humorous toastmaster. His first toast was to the President of the United States. He remarked that after-dinner speeches should always begin with a toast to the President, "we are now a nation 14,000 miles wide, 7000 long and weigh twenty-five billion trillion pounds." He then spoke of the wanderings of the Chinamen from the East, across Behring Strait, down to his paradise in Pennsylvania, where he founded a river and a beautiful valley by the name of Lee-High. To show that at least something good had come from Bethlehem, Dr. Wiley then introduced the retiring first president of the Society, Prof. J. W. Richards, who gave an historical sketch of the phenomenal rise and activity of the Society.

Dr. Wiley then told a lot of jokes about Ann, to arrive finally at Ann Arbor, and introduce the new president, Prof. Henry S. Carhart, to speak of affinity and alliance, as he came from the University of Michigan, which for years has been wrestling with the question of co-education. Other speakers were the retiring secretary, Mr. C. J. Reed, of Philadelphia; President Charles W. Needham, of Columbian University, and Col. Samuel Reber, of the War College, who asked the banqueters to drink the health of wives and sweethearts.

At the conclusion Dr. Wiley read the following telegrams, all stated to have been received by Prof. N. Munroe Hopkins, and expressing regrets at the inability of the senders to be present. The last one was written on asbestos, and had been transmitted by the "Subterranean and Astral Postal Telegraph Company:"

Goettingen, April 8—Afraid to attend another banquet of the Electrochemical Society. Have struggled for a year to understand Wiley's joke of last year. What did he mean by "A. E. S."? Prepay and cable answer.—W. Nernst.

Llewellyn Park, April 8—Sorry can't be at banquet to-night. Detained finishing storage battery which will drive motor car 500 miles. Car can easily be returned by freight.—T. A. Edison.

Berlin, April 8—Regrets at not being able to be present at banquet to-night. Financial osmotic pressure high, which phases me considerably.—J. H. Van't Hoff.

Styx, April 8—Sorry cannot come to-night. Important business with my large sulphur plant products. How science has grown since my time! I see Graham Bell is also flying kites. Kindness of Charon.—Benjamin Franklin.

In the following we give a concise report of the papers presented at the meeting and the discussions which followed:

Standard Cells.

The first paper was presented by Dr. F. A. Wolff, of the National Bureau of Standards. Since the International Electrical Congress to be held in St. Louis will probably take some action in redefining the fundamental electrical units, the author gave a review of the present situation. The speaker first gave the definitions adopted at the Chicago Congress for the three fundamental units, and remarked that the Chamber of Delegates, in which the leading governments were officially represented, recommended the definitions which they drew up as a basis for international legislative enactment. However, comparatively few of the countries have enacted laws defining the fundamental electrical units; and those countries which have are far from being in accord.

The chief objection which is to be made against the suggestions of the Chicago Congress, is that since the three units are connected by Ohm's law, only two are independent, and the third should be defined in terms of the other two. Moreover, since the Chicago Congress, it has been found that the specifications for the silver voltameter are entirely inadequate; redeterminations of the e. m. f. of the Clark cell gave values nearer to 1.433 than 1.434 volts. Finally the application of the potentiometer method to measurements of current and e. m. f. and the improvements in the method for measuring low resistances have set a standard for accuracy for relative measurements of the fundamental quantities far in excess of that fixed by the reproducibility of the fundamental standards.

Of the three units, ohm, volt and ampere, the specifications for the ohm are almost free from criticism and may be made entirely so by the adoption of slight modifications. The ohm will therefore certainly be one of the two fundamental units to be concretely defined. For the second one, we must therefore take either the ampere defined in terms of the silver voltameter, or the volt, defined in terms of the standard cell. The arguments in favor of the former are mostly based upon the assumption of Faraday's law as a fundamental law of nature; while this may be the case, yet numerical applications of the same are based on the supposition that only the one reaction under consideration is taking place, and that no other reactions are going on simultaneously. But in practice it seems that such other reactions play a not unimportant part where the highest precision is sought. Recent researches of Dr. Karl E. Guthe of the Bureau of Standards seem to indicate, however, that the ampere may be defined in terms of the electrochemical equivalent to an accuracy of possibly one part in 40,000, which is considerably greater than the accuracy with which, up to this time, the standard cell can be reproduced.

There are, on the other hand, a number of practical objections to the choice of this method of defining the second fundamental unit. With a given silver voltameter, only currents lying within certain narrow limits can be accurately measured. The duration of the measurement must be great enough to get sufficient silver deposit for exact weighing, and to permit the time to be measured with sufficient accuracy. Tedious double weighings must be made to determine the amount of silver deposited. The result finally obtained gives the average value of the current employed, and cannot be utilized for the accurate measurements of other currents, except by reference of the result to a standard cell, and standard resistance, or to an electrodynamometer, in which case the accuracy is not as great as by a direct reference to the standard cell, even in its present state of reproducibility.

The points in favor of the choice of the volt as the second fundamental unit, and its definition in terms of the standard cell were then summarized by Dr. Wolff as follows. Any voltage may be directly measured without any difficulty in terms of the standard cell by means of the potentiometer with an accuracy practically limited only by the accuracy of its calibration and the reproducibility of the cell. The accuracy with which the standard cell can be reproduced, has for some years exceeded all practical requirements and is still open to greater accuracy by specifying more precisely the manner of purification and preparation of the materials employed. The resulting definition of the ampere in terms of the ohm and volt corresponds to the actual method employed in precision measurements of current intensity by the potentiometer method. Only a few moments are required for a measurement and the method is applicable to the measurement of currents of any magnitude, the practical limit being fixed by the carrying capacity of the resistance standard through which the current is sent. The accuracy is limited only by the errors of calibration of the apparatus employed.

The Clark and Weston cells are the only ones which are to be considered. Investigations thus far recorded indicate that differences between individual cells of either type, set up from materials obtained from various sources, agree with each other to within 0.0002 volt, corresponding to a slight advantage in favor of the Clark cell on account of its higher e. m. f. The standard of cells of either type is equally satisfactory.

While both the Clark and Weston cells have thus the essential qualities for standard cells, yet the Weston cell has the following important practical advantages. The high temperature coefficient of the Clark is a serious obstacle to measurements of the highest precision, while that of the Weston cell is at ordinary temperature less than one-twentieth as large, so that errors due to temperature uncertainties are correspondingly reduced. Another source of error in Clark cells is that due to hysteresis attending temperature variations which in cells a number of years old may be very considerable. In the Weston cell the equilibrium is more rapidly established, and the error can never be as large. The average life of Clark cells is quite short, owing to the tendency of the cell to crack at the point where the platinum terminal is fused in at the amalgam limb; this may be obviated by a modification in construction, but not without introducing complications. In Clark cells a layer of gas is formed at the amalgam surface, even when carefully neutralized solutions are employed. This would interrupt the circuit, thus rendering the cell useless. In the Weston cell no gas is formed. For these reasons the author is certain that the Weston cell will displace the Clark cell.

PHOTOGRAPH TAKEN AFTER THE FRIDAY SESSION

The author then took up the important question of standard methods of purification or preparation of the materials employed in standard cells. He gave rules for the preparation of pure zinc, cadmium, zinc sulphate, cadmium sulphate, and finally mercurous sulphate. The last one is of the greatest importance, since the experience of former observers has shown that the main source of variation in the e. m. f. of standard cells is due to the mercurous sulphate.

The relatively slight changes in the e. m. f. of Clark and Weston cells, produced by small inverse currents, seem to indicate that mercurous sulphate is formed at mercury electrode under these conditions. An experiment was accordingly made to test this. It was found that with neutral solutions a basic salt containing also mercuric compounds was formed at the mercury anode, while with an acidified solution a beautiful crystalline product was obtained. When the solution is stirred, larger current densities may be employed, and in addition there is less tendency for the formation for basic salts due to the accumulation of the product over the surface of the mercury. A most satisfactory product is obtained by the use of a 5 per cent sulphuric acid solution and a current density of 0.1 ampere per square decimeter. With higher current densities there is a tendency for the mercury surface to oxidize and tarnish, and there is danger of the formation of mercuric sulphate.

The apparatus employed by Dr. Wolff and exhibited at the meeting consists of an outer crystalline dish containing a second crystalline dish, of smaller diameter and height, in which is placed a shallow plate having a diameter one or two centimeters less. On the latter is placed pure double distilled mercury which forms the anode, and in the space between the two crystallizing dishes is introduced a layer of mercury forming the cathode. Five per cent sulphuric acid is then introduced to a depth such that the inner dish is submerged to a number of centimeters. The liquid is stirred by a glass stirrer, driven by a motor, on the shaft of which is also a shield to prevent metal particles from the bearings from falling into the cell. The stirring should be vigorous enough to prevent the whole surface from being covered with the mercurous sulphate formed and to keep the mercury in motion. Connections to the current supply are made by means of glass tubes with platinum terminals fused into one end and filled with mercury. To reduce the loss occasioned by the mechanical carrying of the mercurous sulphate out of the inner dish, the latter is covered with a third crystallizing dish, which is inverted and has a hole in its center to permit the introduction of a stirrer and the anode connection. The product formed collects under the rim of the plate, and may be subsequently collected.

The sulphuric acid solution contains no trace of mercuric salts. The mercurous sulphate itself contains no mercuric salt, and since it is obtained from pure mercury and pure sulphuric acid it is hardly likely to contain any other impurities.

It has been suggested that the size of the grain of the mercurous sulphate may have some influence on the electromotive force of the standard cell, which is quite likely the case when the grains are small, owing to difference in solubility. With the mercurous sulphate produced by the electrolytic method, the crystals are fairly large, as shown by their rapid sedimentation, and there is little likelihood that there will be any difference due to this cause.

The author emphasizes again the very marked superiority of the Weston cadmium cell with saturated solution over the Clark cell which should certainly lead to the entire displacement of the latter. He urges that the saturated Weston cell should be adopted as one of the fundamental standards, if the St. Louis Congress should decide on defining the volt in terms of the standard cell. As a working standard of the e. m. f. the portable cell sold by the Weston Electrical Instrument Co., in which the solution is saturated at 4° C., and which does not contain any excess of cadmium sulphate crystals, can hardly be excelled. A number of such cells have been under constant observation at the Bureau of Standards, and show differences in the course of a year and a half, not exceeding a few parts in 100,000. This constancy, together with a temperature coefficient so small that it may be neglected in all but measurements of extreme precision, makes it fulfill all the essential requirements of a secondary standard. In addition, the use of

such cells simplifies the construction of potentiometers, as no provision has to be made for variations in e. m. f. with temperature, and the potentiometer current can therefore be adjusted by applying the cell to the terminals of a fixed resistance.

Preparation of Materials for Standard Cells and Their Construction.

The next paper on the programme, by Prof. Henry S. Carhart and Dr. George A. Hulett, was presented by Prof. Carhart, who emphasized that in the preparation of standard cells the chemical side of the problem has hitherto received too little attention. The authors first gave standard methods for preparing mercury, cadmium sulphate, cadmium amalgam, and then described a new method which they have developed for making mercurous sulphate by electrolysis. Their method is in all fundamental points identical with that developed independently by Dr. Wolff, although differing in details. The object is to secure Hg_2SO_4 free from nitrate, using only mercury and sulphuric acid, and to secure at the same time a sufficiently rapid reaction without the use of a strong acid. This led them naturally to the electrolytic method which is described as follows:

In a flat-bottomed beaker or deep crystallizing dish is placed mercury a centimeter or so deep. This is covered with dilute sulphuric acid (one to six) to the depth of some 10 centimeters. A platinum wire, protected, except at its end, by a glass tube, makes contact with the mercury, which serves as the anode; the cathode is a piece of sheet platinum in the H_2SO_4 solution. A current of about 0.3 ampere is passed from the mercury into the solution; crystalline mercurous sulphate at once begins to separate on the surface of the mercury. A stirrer, consisting of a glass rod, bent at right angles at the bottom, must be used to keep the mercury surface exposed. The foot of the stirrer passes close to the mercury, and must be driven rapidly by a motor.

HENRY S. CARHART,
President American Electrochemical Society.

About 2.8 gm. an hour can be prepared in this way. The sulphate should be protected from the light. By means of a separate funnel the excess of mercury may be readily removed from below, leaving the sulphate with more or less finely divided mercury mixed with it. The preparation is often somewhat gray on account of the presence of mercury in a state of fine division. This mercury is a distinct advantage, because it insures the absence of the mercuric salt.

The authors recommend this method strongly as a standard preparation of mercurous sulphate. It gives a lower e. m. f. with mercury than any preparation obtained from $HgNO_3$ and H_2SO_4 or a sulphate. Samples made at different times and with different materials show an exceedingly close agreement. The authors add the precaution that the sulphate formed during the first few hours should be rejected unless one is sure of the purity of the mercury. After the electrolysis has proceeded for some time, the solubility of the mercurous sulphate is put in evidence by the appearance of mercury on the platinum cathode.

While Dr. Wolff had established the chemical purity and uniformity of the electrolytically prepared mercurous sulphate, Messrs. Carhart and Hulett have gone further, and have actually employed it in Weston cells. They give the following rules for the construction of a cadmium cell. The H-form of cell is the most convenient to fill; and the method of sealing the cell with small blast flames is so simple that the two legs may be hermetically sealed at the top without the least danger of affecting the contents of the element.

The glass parts can be readily made by anyone possessing a little skill in glass-blowing. Fig. 1 shows the cell ready to be filled. The tubing is drawn out and contracted at *a* so as to leave the diameter about 6 mm. and with thin walls at this point. Fragments of the cadmium amalgam may be introduced into the clean dry cell, and may then be melted by dipping the leg of the cell into hot water; or the amalgam may be melted under cadmium sulphate solution, and may then be introduced in the liquid form by means of a small tube, slightly contracted at the end, and of a diameter that will allow it to pass freely through the neck *a*. This tube is used as a pipette; it permits the melted amalgam to be introduced rapidly and without splashing. The mercury, the thin paste, and the concentrated cadmium sulphate solution may be introduced in the same manner. An alternative method is to introduce the materials through little funnels made out of small test tubes. The funnels must pass through the neck *a* of the cell and must reach well down toward the bottom.

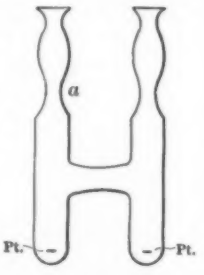


FIG. 1. CADMIUM CELL.

The electrolytic mercurous sulphate, which has stood with mercury under dilute sulphuric acid, is brought into a Gooch crucible, avoiding free mercury, which interferes with the filtering; it is then washed first with sulphuric acid (made by adding 0.5 c. c. concentrated H_2SO_4, density 1.84, to a liter of water), and then with concentrated cadmium sulphate solution. (Dr. Carhart remarked in parenthesis in this connection that water is a most dangerous thing for many purposes, even for washing.) It is better to reject the top layer, which may be slightly darkened. The paste is next made in a clean agate mortar by grindnig together crystals of $CdSO_4 8/3H_2O$, and a little mercury, and then mixing in about three volumes of the mercurous sulphate and enough saturated cadmium sulphate solution to make a thin paste. After the mercury under dilute sulphuric acid, is brought into side of the cell, both legs are filled up to the cross tube with the dry, clean crystals of $CdSO_4 8/3H_2O$. Enough of the saturated cadmium sulphate solution is finally added to fill the cell to the top of the cross tube. The sealing-off is readily done by means of two small horizontal blast flames, 3 cm. long, directed in a line toward each other and just meeting. The narrow part *a* of the cell is brought between the impinging flames, the glass quickly softens, and the top part is drawn off. There is no noticeable heating of the contents of the cell; but it may be advisable, before one has acquired the proper skill, to protect the cell by an asbestos disc fitted to the tube below the point *a*. The disc is not necessary if the cell is made like the one shown in Fig. 1. A cell sealed in this way contains nothing except the materials of the voltaic combination. It cannot leak, and can be immersed in kerosene without danger of the oil getting inside. A perfect seal has always been a most difficult thing to secure.

The authors give in tables the results obtained with such cells, and these are extremely good. A series of cells set up in January do not appear to have changed since then by more than one part in 100,000, and the agreement among themselves is exceptionally good. The e. m. f. is 1.01908 international volts at 21.1° C. These cells do not require any ageing process to reach their equilibrium e. m. f., but reach it immediately. This is quite different from the behavior of cadmium cells in which other kinds of mercurous sulphate are used. The author

finally expresses his opinion that mercuric ions are always present, and that there is always equilibrium between mercury, mercurous ions and mercuric ions. Quite recently, the authors have set up fifteen Clark cells with the new mercurous sulphate, but the results were not yet given.

In the discussion which followed, Mr. H. N. Potter asked what kind of glass the authors had used for the containing vessel. Glass is not a well defined substance, and since we have now quartz-glass, we could use it. Under these circumstances there could be no changes from country to country on account of differences in the glass. Prof. Carhart replied that he thought they had always used the same glass for the cells, but had not considered this to be very important, since they did not expect much variation from the glass. Dr. J. W. Richards asked about the accuracy in determining the temperatures, whether a mercury or gas thermometer was used. Prof. Carhart replied that this was not of very great importance for the Weston cell and a good mercury thermometer is sufficient. Dr. F. A. Wolff stated that he had not yet set up cells with the electrolytic mecurous sulphat, but from its crystalline character and from its chemical purity he considered it specially suitable for standard cells. Prof. Carhart suggested that if the cadmium cell is adopted as a standard of e. m. f. we should call the saturated type, with an excess of crystals, the "Weston cell, primary standard," and the other unsaturated type we should call the "Weston cell, secondary standard." Mr. Carl Hering asked whether there is not an uncertainty introduced by hermetically sealing the cell, since this might produce a change of pressure which might react upon the e. m. f. Prof. Carhart replied that this was apparently disproved by the uniformity of the results obtained; moreover, from the construction of the cell there can be no difference of pressure at different points of the cell. The hermetically sealing of the cell is done near 20° C. Dr. Richards concluded from this that the pressure inside the cell must be smaller at ordinary temperature.

SINGLE POTENTIALS OF THE HALOGEN ELEMENTS.

A paper on this subject was presented by Mr. WILLIAM ROY MOTT, who pointed out that "there are many points in the ionization theory not in harmony with some facts observed in the study of single potentials." He thinks that "the impossible solution tensions assigned to metals tend to blind one to the fact that the actual chemical reaction taking place, and its free and bound energy are the essential points." Dr. Patten and the author have calculated the single potential of chlorine for dilute aqueous solution as —2.00 volts. By similar methods the author has calculated the single potentials of the other halogen elements: Iodine,—0.89 volts; bromine,—1.53 volts; fluorine, —2.53 volts, all being referred to Ostwald's zero. The author then discussed decomposition voltages and gave a diagram reproduced in Fig. 2, with the decomposition voltages as abscissae and the single potentials of the metals as ordinates. The decomposition voltages are calculated from the thermochemical data simply by Thomson's rule. This diagram represents the well-known additive law. Equal increments mark the displacement of one metal by another metal, or of one halogen element by another halogen element. This results in two sets of parallel lines. This diagram can be used in the calculation of any one of the factors—the total decomposition voltage, the single potential of the anion, and the single potential of the cation—when the other two factors are known, but it must be remembered that the formation of normal salts in dilute aqueous solution is postulated.

The author then discussed the various experimental determinations of the single potentials of the various anions, the values of which were given above. In conclusion the author stated that the additive law holds much better for dilute aqueous solutions than for solid salts. Solid salts may, in different forms, possess very different amounts of energy; for example, amorphous silver iodide has a heat of formation of 6.6 large calories, while the crystalline variety has a heat of formation of 16.2 large calories. This introduces a difference of 0.33 volts in their corresponding decomposition voltages.

The difference between the decomposition voltage of the solid salt and of the dissolved salt represents the heat of solution or the energy of the reaction resulting from the affinity of the salt for the solvent. Other solvents than water have very different heats of solution. Solubility is largely determined by the mutual affinity of the solvent and solute as represented by the heat of solution.

Dr. R. Gahl remarked that the method of the calculations of the author is in some points open to objections on the basis of the principles of thermodynamics. Mr. Mott replied briefly.

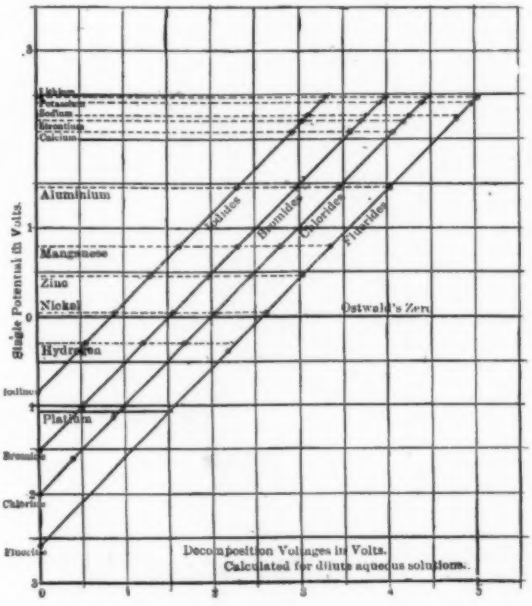


FIG. 2. DIAGRAM OF DECOMPOSITION VOLTAGES.

THE CONTINUOUS ADVANCE OF ELECTROCHEMISTRY.

At a special meeting held on Thursday evening, the retiring president, Prof. J. W. RICHARDS delivered his presidential address on the above subject. He remarked that the field of electrochemical activity covers three distinct lines of endeavor, namely, investigation and classification of electrochemical phenomena; the building of a comprehensive electrochemical theory; and the application of electrochemistry to industrial needs. He discussed briefly the past achievements in each of these main fields of electrochemical activity, in order to determine therefrom and to discuss more at length the present bent and probable future direction of each.

Concerning the experimental investigation and classification of electrochemical phenomena he expressed the opinion that electrochemistry has lost much in the past by lack of co-ordination and co-operation of electrochemists. An attempt to give a complete summary of what has been done in the past is now being made in the German Handbuch, which is in course of publication. On the other hand, the foundation of electrochemical societies in this and other countries will bring good fruits, since it is their function to bring electrochemists together. There has been an army of investigators in the past, but the results would have been more valuable if the army had really been an army directed by a leader. There are now large gaps in our experimental knowledge of the various fields of electrochemistry, and these must be filled by experimental research in the near future. Dr. Richards gave a list of many subjects which need systematical attack and orderly study; among them are investi-

gations of the electric conductivity of some common salts, of fused salts, of solutions of salts in fused solvents, the use of accurately controlled electrodeposition for the purpose of determining the chemical equivalents of metals; the calorimetric determination of electrolytic cells in operation; the deposition and solution of alloys; the behavior of mixed electrolytes; the relation of viscosity to conductivity; the solubility of metals in their own fused salts; the modus operandi of porous diaphragms. The author referred to the work of A. A. Noyes on electric conductivity of solutions at high tempera- and to that of L. Kahlenberg on non-aqueous solutions.

Concerning the evolution of a comprehensive electrochemical theory, Dr. Richards expressed the opinion that we are now in a transition status. We know what we are abandoning, but we do not know what we are getting at. Scientific theories must always be in a constant flux. Concerning the dissociation theory he said that he does not know whether it is true, but that it would be wrong to claim that it is certainly true. His own conception of the state of a solution is that the solute is in an abnormal physical state, having resemblance to the gaseous state, and that in some cases a definite compound of the solute with the solvent exists in solution, it also being in the abnormal physical but not abnormal chemically. Large generalizations are very seldom proven directly false. Facts accumulate as evidence of the inefficiency of a theory in certain directions. From J. J. Thomson's recent work on the structure of atoms one might think that the ionic theory might be replaced by the electronic theory. The author referred to J. H. L. Vogt's investigations on the nature of fused silicates. The physical solution of one substance in another covers a large field of what was formerly considered to be entirely chemical in its nature. The eutectic mixtures resulting are in no sense chemical compounds.

JOSEPH W. RICHARDS,
Retiring President American Electrochemical Society.

The concluding part of the lecture dealt with the application of electrochemistry to industrial needs, the author briefly referred to the most important electrochemical industries, like copper refining, the manufacture of calcium carbide, aluminium, sodium, alkali and bleach, chlorate. Electrochemical methods represent a new instrument for getting old or new results. In the electric furnace we can produce temperatures which were never before thought practical. Among the electrochemical processes we may distinguish those methods applied to the more powerful chemical compounds which cannot be easily decomposed by other means; high temperature reactions; ordinary chemical processes in which the directness of the electrochemical influence is deciding. The author gave examples of these three classes. The first comprises the treatment of those fixed and difficultly transformable compounds of strong metals, of large occurrence in nature. What electrochemical methods can do in this respect is evidenced by the history of the metallurgy of aluminium, which shows the potentiality of electrochemical methods for improvements. After the purely chemical process had spoken its last word concerning the manufacture of aluminium, electrochemists started and won the day. Dr. Richards referred at some length to the production of metallic silicon on a commercial scale by the Tone process in Niagara Falls. Only by electrochemical methods it is possible to get cheap silicon, which occurs in its compounds in an enormous amount on the earth. The problem is now to find uses for silicon just as it was ten years ago to find uses for aluminium. While the electrochemist is the reverse of a nihilist he is a typical and convicted revolutionary.

The maufacture of steel by electric furnace methods is most promising in countries where fuel is dear and power cheap, and afterwards in localities where very cheap power is being generated by gas engines using either the waste gases from blast furnaces or producer gas made from coal waste or culm. Even before that time the auxiliary use of electric heating to take off "the peak of the load," so to speak, in our open-hearth steel furnaces, that is, to furnish the last few hundred degrees of necessary temperature, while the combustion of gas furnishes the lower range, is a distinct commercial possibility. Already our steel plants are a network of electrical appliances for running cranes, charging machines, hoists and cars, and the step is not a long one to employ this already present agent to help the heating gases over the heaviest part of their work, the bringing up of the charge to tapping heat.

The author briefly referred to electrochemical methods producing calcium, magnesium and beryllium. We are only beginning to appreciate the possibilities of calcium which is the most powerful pyrochemical agent at temperatures, above red heat, the strongest metallic base existing. An electrolytic production of magnesium would reduce its price enormously and enlarge very considerably its uses. There would be a large number of applications for beryllium if it could be obtained cheaply. Calcium carbide is practically a new compound, but it is only one of numerous carbides, carborundum being another one. Other carbides may equally find applications.

The author referred to a remark made to him by one of the most vigorous and industrious electrochemists that we are so overwhelmed by new things of possible use to science and industry that we can at most investigate only a small fraction of them. Electrochemistry is a virgin continent of undeveloped possibilities. The great services which electrochemistry has rendered humanity and the march of civilization in the few decades which measure its brief but phenomenal advance, are but a fraction of what is yet to be accomplished. The author concluded his address as follows: If in the battle of industrial competition, you are summoned by the conservatives of industry to strike your colors, answer with a courage and determination of the intrepid Captain John Paul Jones, "Surrender, sir? We have only begun to fight."

The Composition and Resolution of Voltages.

The first paper of the Friday session was presented by Prof. J. W. Richards on the above subject. It contained an elaboration of the theory developed by him in a former paper read before the Philadelphia section of the Society (abstracted in Electrochemical Industry, March, 1904, p. 95). The problem discussed by the author is how to generalize Thomson's rule so as to apply to the case that several different electrochemical actions are simultaneously going on. The author, therefore, does not pretend that his theory is of greater exactness than the original Thomson's rule since any thermoelectric effect is purposely neglected.

The author discussed his method on the basis of examples taken from commercial practice. He first considered the case that several actions are simultaneously going on at the anode, i. e., what he calls the composition of voltages at the anode. His first example was the refining of impure metals, and he dealt with the case of an impure copper anode, containing 90 per cent Cu, 5 per cent Fe, 1 per cent Ni and 1 per cent Zn. If the materials in the anode dissolve in this ratio, then, if we base our calculations on a certain number of coulombs passing

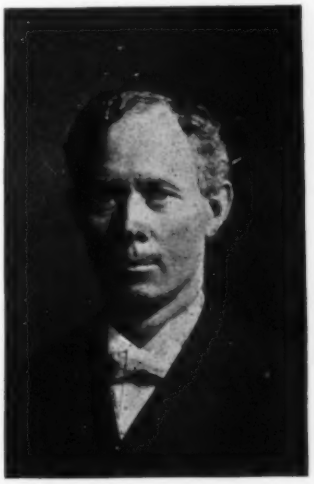
through the tank, we can calculate the amount of copper, iron, nickel and zinc passing into the solution at the anode. For each of these four different anodic reactions the cathodic reaction is that an equivalent quantity of copper is deposited. Now it is easy to calculate from thermochemical data the energy corresponding to each of these four reactions. If we neglect concentration differences at the two plates, the solution of copper at the anode, and the deposition of the same amount of copper on the cathode neither consumes nor evolves energy. The other three reactions evolve energy (each of them could be used separately for making a primary cell). If we sum up the energy evolved by the last three reactions and give the figure in joules or volt-coulombs, and then divide this figure by the number of coulombs which we have taken as the basis of the whole calculation we get the "composite voltage" of the total process. Prof. Richards finds that the last three reactions represent an assisting voltage of + 0.065 volt; copper refining would therefore need no external energy under these conditions, if there was not a loss of volts due to the internal resistance of the cell and also a loss of volts due to concentration differences at the two electrodes. His second example was the numerical calculation of the solution of a copper-nickel anode with the deposition of copper on the cathode. This is one of the steps of the Browne process (ELECTROCHEMICAL INDUSTRY, July, 1903, page 382).

The author then discussed the case that at the anode only one action takes place, while several reactions occur simultaneously at the cathode. The first example given was the electrolysis of a mixed solution of copper nitrate and silver nitrate, with a pure copper anode and deposition of a copper-silver alloy on the cathode. Another example is when in the cathodic deposition of a metal hydrogen simultaneously appears at the cathode. Thus, in depositing copper from an aqueous solution, the voltage is constant as long as only copper is deposited. If, however, the solution becomes poor in copper near the cathode (perhaps on account of high cathodic current density), then we have both deposition of copper and evolution of hydrogen, and the voltage begins to rise according to the ratio of the amounts of copper and hydrogen deposited on the cathode. The author emphasized again that his method of combining and resolving voltages is essentially a method of combining and resolving energies.

In the discussion Mr. Lawrence Addicks stated that Dr. Richards' theory well represents what is observed in copper refining. Mr. W. R. Mott remarked that various points might change the calculations; for instance, concentration changes. Sometimes we have at the anode a purely chemical dissolving action (local action). The heat of alloying should also be taken into account as it is sometimes large; also the so-called over-voltage. Mr. Carl Hering thought that Dr. Richards' calculation appears to be based too much on theory. In the example of copper refining where zinc and iron are in the anode there would be surely local action. He thinks those factors which are not considered in Dr. Richards' theory may become in practice great compared with the small amount of voltage calculated by him (0.065 volt in the copper-refining case) so as to obscure entirely the results of his calculations. Mr. Reed remarked that the actual figures calculated by Dr. Richards in several cases agree almost absolutely with what he has found by experiment. Dr. R. Gahl said that if one makes a calculation on the basis of the ionic theory, the results would be different from those of Dr. Richards' calculation; he expressed this by stating that while Dr. Richards' law calls for a straight line in a certain case, the ionic theory would call for a bent curve. Mr. Reed stated that according to experiments, the curve in that case is practically a straight line. Mr. Addicks stated that the experience in copper refining speaks against Dr. Gahl. Dr. Gahl replied that his curve is based on the assumption that no alloy is formed, and that to apply it to practical results, it must be modified. Mr. Hering referred to a method of depositing zinc without hydrogen. Dr. Richards replied that for applying his theory to practical cases, of course, such factors like heat of alloying, the e. m. f. loss due to internal resistance must be taken into account, but he was purposely not dealing with them in his paper. He also stated that his paper is not altogether theoretical since he has often observed such results as he has calculated. Replying to Dr. Gahl he said that in his calculation he assumes a continuous process, like that of Browne, while in a case like that assumed by that of Dr. Gahl the constitution of the electrolyte continually changes and one component is gradually more and more exhausted.

MOLECULAR CONDUCTIVITY.

In a paper on this subject Mr. C. J. REED emphasized that electrical conductivity is a property of matter, which, like transparency, diathermacy, magnetic permeability and heat conductivity, can be measured and compared in different substances only by employing a unit in which there is a definite section, across which the flux is measured, and a definite length in the direction of the flux. Units of this kind must be defined by certain relations of form, in which the ratio of length to cross-section is a fixed ratio. It is, for example, impossible to compare the conductivities of iron and copper by measuring the conductance of a pound of iron and the conductance of a pound of copper, without any reference to form, or dimensions. What is true of a pound of iron or copper is equally true of a granimolecule. But Mr. Reed thinks that those electrochemists who talk about the molecular conductivities of solutions in different degrees of dilution absolutely lose sight of this fact. "The conductance of a liter of solution, containing a grammolecule is measured in the form of a flat prism, one centimeter thick and having a crosssection of ten square decimeters. This conductance is taken as the conductivity of the normal solution. Dilutions are made by adding water and spreading out the increased volume, whatever it may be, into a flat plate of the same thickness, one centimeter, and increasing the cross-section in proportion to the increased volume. The conductances of these extended volumes measured between the parallel sides are called 'molecular conductivities' merely because the measured volumes contain a grammolecule of the solute." He compares this with a method in which one would measure the conductance of a certain cube of silver between opposite faces, would then fuse the silver with 200 times its volume of lead and measure the conductance of the resulting alloy between faces having 200 times the area of the original faces, and would then conclude that the conductance so measured represents the molecular conductivity of th silver in the two conditions of concentration.



CHARLES J. REED

Retiring Secretary American Electrochemical Society

Mr. Reed claims this is what is done by the electrochemist when he speaks of the molecular conductivity of solutions. He emphasizes that in an aqueous solution one cannot say that it is the solute alone which conducts the current. Mr. Reed thinks that the use of deductions based upon quantities like molecular conductivity have been very harmful, since they have produced a fundamental confusion in the development of the electrolytic dissociation theory. He quotes several state-

ments from which he concludes that in books on the dissociation theory the term conductivity is often used where we should read molecular conductivity and that moreover the conclusions on the increase of the degree of ionization with dilution is based upon such a confusion. Mr. Reed argues that the increase in molecular conductivity with increased dilution does not require any increase in "conducting power" and, consequently, does not require any increase in the number of ions. He argues that the conducting power (meaning evidently the conductivity) and, therefore, the number of ions rapidly diminish with dilution, but the change in the form and dimensions of the conducting mass caused by increasing dilution, according to the method used in molecular conductivity measurements, results in measurements of conductance which slowly increase with dilution. Mr. Reed concludes that in view of the facts it seems to him that the term "molecular conductivity" and all theoretical deductions based on investigations of molecular conductivities of different degrees of dilution have no physical significance.

In the discussion Mr. Carl Hering said that one finds in practice often loose statements, and that one should carefully distinguish between conductance (measured in reciprocal ohms) and conductivity. The conductance of a body depends upon its form and the direction of the current while the conductivity of a substance is a property of matter.

Dr. E. F. Roeber agreed that the general remarks in the first part of Mr. Reed's paper were correct, and their correctness was beyond dispute, but he strongly disputed the conclusions drawn therefrom by Mr. Reed concerning the method of measuring molecular conductivity of solutions and concerning the validity of the dissociation theory. He gave a mathematical development to show that if we once accept the model of traveling ions, we are lead with absolute consequence to an equation, stating that conductivity equals concentration (in gram equivalents per liter) multiplied by i multiplied by $u + v$, where u and v represent the mobilities of the cation and anion, respectively, and i represents that proportion of the dissolved molecules which takes part in the conduction of the current, or, in other words, the degree of ionization. In this equation a constant factor is left out which depends only upon the units chosen. From this equation it follows directly that molecular conductivity, *i. e.*, the conductivity divided by concentration, equals i multiplied by $u + v$. What we measure in practice, is always a conductance, but from the conductance we can calculate the conductivity, and by dividing it by the number of grammolecules per liter we get the molecular conductivity. The method of measuring molecular conductivities which is attacked by Mr. Reed follows directly from the definition of molecular conductivity since the cross-section across which the conductance is measured is inversely proportional to the concentration. What is found by experiment is that the molecular conductivity increases with increasing dilution. Hence, according to the above equation, $i\ (u + v)$ increases with dilution. If we assume that all dissolved molecules participate equally in the conduction of the current through the electrolyte, then i is unity and we must conclude that the mobilities u and v increase with dilution; this is how Kohlrausch first expressed his experimental results. If, however, we assume Arrhenius' theory that only a certain number of the dissolved molecules transport the current, and that the mobilities u and v are independent of the dilution, then since $i\ (u + v)$ increases with dilution, and u and v are constant, it follows that i must increase with dilution, that is that the degree of ionization i increases with increasing dilution, and nothing more has been claimed in the statements attacked by Mr. Reed. There is, therefore, no confusion whatever concerning this point. But even if we do not accept the model of traveling ions it would be wrong to deny the physical significance of molecular conductivity. If we consider the conductivity of a dilute solution as a function of the (large) amount of solvent a and of the (small) amount of solute b, then we may develop the function in form of a series and need to consider only the first two terms on account of the supposition that the solution is very dilute. We get $f(a + b) = f(a) + b\,f'(a)$, where f' means the first differential quotient. In the case of water we may approximately assume the conductivity of pure water to be zero, so that $f(a)$ becomes zero, and we see that the molecular conductivity is represented by $f'(a)$. For more exact measurements we cannot neglect the conductivity of water, but must subtract it from $f(a + b)$. This is what Kohlrausch did in working out his results.

Dr. R. Gahl thought that Mr. Reed's difficulty might be due to the fact that if we want to calculate molecular conductivity for infinite dilutions, we have a quotient of the conductivity (which for infinite dilution becomes not zero, since pure water has a certain conductivity) to the concentration (which becomes zero at infinite dilution). This would lead to an infinite value of the mobility, but this result is wrong, since we must deduct the conductivity of the pure water from the conductivity of the solution; this is what Kohlrausch does. Dr. J. W. Richards thought it was objectionable to simply subtract the conductivity of the pure water from the conductivity of the solution. Dr. Gahl replied that this method is correct for very dilute solutions, and is justified by the consistent results obtained by Kohlrausch. Col. S. Reber thought that the formula molecular conductivity equals $i\ (u + v)$ is only a mathematical expression, the physical significance of which might be denied. Dr. E. F. Roeber replied that the physical significance of the i, considered as degree of ionization, is emphasized by the fact that for very dilute solutions, measurements of the lowering of the freezing point or of the raising of the boiling point give us the same values of i which we find from molecular conductivities.

The Economic Balance in Electrolytic Copper Refining.

A paper on this subject was then presented by Mr. Lawrence Addicks of the Raritan Copper Works. He remarked that probably few persons not in daily contact with refining work realize the close interdependence of relations which forms what he terms the economic balance. He proposed to indicate these relations and their bearing on the cost of production. The problem may be separated into three variables—tank resistance, age of electrodes and current density.

Tank resistance is made up of metallic conductors, contacts, anode slimes, counter e. m. f., electrolyte and a negative quantity due to imperfect efficiencey. The metallic conductors consist of the leads from the generators, the circuit bars and rods supporting the electrodes, and the electrodes themselves. The chief item here is in the circuit bars running from tank to tank. This resistance can be lowered either by increasing the section of the bars, or by increasing the number of tanks abreast. The first method is limited by the cost of the copper required; the second involves a consideration of the increased labor cost due to inaccessibility, the loss in output caused by the increased number of tanks which have to be cut out of electrical service when changing electrodes or removing slimes, and, finally, the saving in first cost of plant.

The loss from contacts depends on their number, the weight bearing down and the condition in which they are maintained. The number depends upon whether or not the anode is provided with supporting lugs—if so, the weight of scrap made is proportionately increased. The average weight depends on the age of electrodes. The condition is governed by the labor expended in shining, and by the exposure to moisture and fumes, or, in other words, by the temperature of electrolyte. The resistance due to slimes adhering to the anode is a very variable one, and depends, of course, upon the thickness of the layer allowed to form upon its surface. Very impure anodes and a high current density give great trouble. Counter electromotive force is due chiefly to the difference in concentration at the electrodes. Circulation tends to check this, but no amount of circulation will obliterate it.

The resistance of the electrolyte itself depends upon composition and temperature. Resistance varies greatly with changes in the chemical composition. In deciding upon the composition to be maintained, we are governed largely by the impurities in the anode copper. Arsenic is the most difficult to handle. With small quantities of arsenic present in the anode the electrolyte may be maintained reasonably pure without a special purifying process, the quantity of arsenic slimed balancing that introduced at the anode before the per cent arsenic in the solution reaches a troublesome amount. A high current density magnifies these difficulties. The amount of copper carried as sulphate by the electrolyte must be sufficiently in excess of the arsenic to insure satisfactory purity in the cathode at the tank voltages existing. In free acid contents we are also limited by the decomposition point—a percentage at which electrolysis of water commences with resulting polarization.

The temperature coefficient is large, and we have a balance to strike between power saving, cost of heating, increased contact losses, and increased cost of keeping the copper contents of the electrolyte down to the required figure. When considering the saving in power from heating the electrolyte, we must not lose sight of the fact that we are dealing with but part of the total resistance of the circuit. Starting at the generator terminals, if we have an electrolyte of low resistance and an anode running high in impurities, the liquid resistance may not greatly exceed 50 per cent of the total. With a different set of conditions it may be 80 per cent, or more, but in any case this factor must be reckoned with. The spacing of the electrodes, or, in other words, the thickness of the liquid column, has a great deal to do with tank resistance; it must be considered in connection with age of electrodes and current efficiency.

A diminishing current efficiency forms an effective, but somewhat expensive, way of arriving at a low tank resistance. It must be remembered, however, when deciding upon the efficiency which it pays to maintain that the loss in output from this cause is accompanied by a certain diminution in total power charges.

As to the question of age of electrodes, much depends upon whether or not the refiner is charged with interest on the metals tied up in the process. If so, he will use a lighter anode than otherwise, though the question of current density must be taken up at the same time. A heavy anode reduces the percentage of scrap and the handling charges, as it is the number of electrodes, rather than the pounds of electrodes that figure in tank-room handling. The heavier the average weight during life the better the contacts. With the cathodes smoothness of deposition is the governing factor, as upon it depends the current efficiency. The smoothness depends upon age, electrode spacing, current density, circulation and composition of electrolyte. On the other hand, as the age decreases, handling charges and the cost of stripping starting sheets runs up. As a partial offset to the increased number of stripping tanks required per hundred depositing tanks, there is the very high current efficiency obtained in these tanks due to the rigidity and low age of the cathodes.

Finally, from the standpoint of current density the problem becomes largely one of output. With any given plant the simplest way to increase the output is to raise the current density. Even our largest plants still have a respectable proportion of fixed charges, and the distribution of these over a larger tonnage is always an attractive proposition. If interest charges are involved, we gain here as well. With a rising density, however, we are met by a rapidly-increasing power cost and a roughening of the deposit. The small counter e. m. f. present keeps the power needed per tank from increasing quite as the square of the current density, but it approaches this ratio. The rougher cathodes require a readjustment of several of the conditions previously outlined, involving a corresponding increase in costs in order to maintain the current efficiency. The circulation must be pushed, and this is followed by increased silver losses in the cathode—a charge which mounts rapidly. 0.1 ounces or 1.5 ounces per ton might be equally good work for different sets of conditions. The increased energy expended in the cell brings the temperature up and helps the tank resistance. As the density increases the relative cost of operating insoluble anode tanks decreases.

In any given case the multiplicity of relations pointed out must be solved, a pair at a time, and a set of final heats run off with the winners. We are very much in the same position as when, in hydraulics, we wish to compute the flow over a weir. The velocity of approach enters into the formula, but this presupposes a knowledge of the flow. We use an estimated flow to find this velocity and then solve the equation for the real flow. This figure is used in computing a corrected velocity of approach and so on till the true value of the flow is obtained. In the light of the foregoing it is easy to see why no two refineries use just the same densities and temperatures and so on. A difference in the cost of labor or power or supplies would tip the economic balance to a new reading at once. The situation varies also according to whether or not the refinery is operated by a copper producer. If it is, interest charges on the metals tied up must be reckoned with and the question of output is not so vital, as it cannot exceed the quantity furnished by the smelter. If the plant is a custom one, operated on a toll basis, a period for refining is usually allowed gratis and interest questions, within certain limits, do not arise.

And, finally, when all is said and done, the lowest cost per ton may not be the cheapest cost per ton. This seeming paradox is due to the fact that with a current density somewhat greater than that giving the lowest cost per ton, the output may be sufficiently increased to give greater earnings in spite of the higher cost per unit.

In the discussion of Mr. Addicks' paper, the secretary presented a written communication by Prof. W. D. Bancroft, who questioned whether Mr. Adicks gives in his paper an accurate statement of the things as they are. Not a series of successive solutions of single parts of the problem should be attempted, but the whole problem should be attacked at once. He thought that Mr. Addicks had not given all the factors, while some of those mentioned by him were relatively unimportant, and pointed out the great difference of operation at the Anaconda and Great Falls plants in spite of the fact that they are near together, so that some conditions are surely equal. Mr. Addicks, in reply, thought that the difference in practice of these two works confirms his views. He pointed out that the final economic balance is the summation of balances. He does not veto a high current density, but only too high a current density. Mr. Carl Hering thought that the only really satisfactory way in case of so many variables is to work out the problem for a great many different conditions; we can then learn much by taking two and two together. Mr. Addicks emphasizes that a final curve for the economic balance can only be obtained by first plotting all the individual curves.

HEAT OF NEUTRALIZATION.

A brief paper by Mr. G. W. WESTMAN was then presented in which some critical remarks were offered on Prof. J. W. Richards' theory of the heat of neutralization, as presented in a former paper (ELECTROCHEMICAL INDUSTRY, 1903, page 491). The author discussed this theory on the basis of a molecular hypothesis of his own. For instance, he considers diffusion as depending on the centrifugal force of the rotary movements of the molecules, which force acts against gravitation. From his point of view he shows that Dr. Richards' method of calculation is open to criticism. He also objects to the statement that ionization is in no sense to be regarded as a resolution or decomposition of the molecules into the constitutents. "As in the case of gases, the ether separates and supports the molecules in exercising the centrifuga.. .orce, so in the case of solu-

tions the water separates the molecules from each other, in order that their centrifugal force can act, which is not possible when they are bound together. When more water is added the molecules expand farther and their constitutents are farther removed from each other, so that the attraction between them grows less."

In the discussion, Prof. Carhart thought that the author's conclusions are based on "most extreme theories." Dr. Richards considered that the last statement of the paper is a confirmation of his own views, namely, that the state of solution is similar to that of gases.

The Energy of Ions.

A paper on this subject was presented by Prof. Louis A. Parsons, of the University of Utah. In the absence of the author it was read by Mr. S. S. Sadtler. The paper was essentially a reply to criticisms which Mr. C. J. Reed had formerly made against the electrolytic dissociation theory on the basis on the energy principle. The author summed up Mr. Reed's argument as follows: "Two oppositely-charged bodies constitute a source of electrical energy. When they are discharged through an intervening medium energy is evolved or work done upon that medium. If, according to the accepted theory, ions are charged, in the formation of atoms from ions, the latter must be discharged, thereby adding energy to the circuit. In all known changes from ions to atoms there is an absorption of energy from the circuit, and not an addition of energy to it. Therefore, ions must be uncharged and atoms charged."

The author's reply to this argument is very long and highly theoretical. He first accepts Mr. Reed's premise as to what the ions are and endeavors to show that if Mr. Reed is right in saying that in all known changes from ions to atoms there is an absorption of energy from the circuit, then the only legitimate conclusion is that ions are discharged and atoms are not, which is diametrically opposite to Mr. Reed's conclusion. The author does not believe, however, that we are justified in considering the ions as spheres or small bodies with positive and negative charges on them, and the atoms as these spheres "discharged" in the sense of having given up their charge to some external body. It does not follow from the ionic theory and is certainly opposed to the electron theory. In a sodium chloride molecule we may assume the sodium atom still combined with a positive electron, and the chlorine ion combined with a negative electron, but we call this molecule electrically neutral, because no electric field is due to the two opposite electrons in the molecule. The author shows how the electronic theory leads to the conclusion that in a solvent of a high dielectric constant the ions in a molecule will tend to separate from each other.

The author then remarks that there is a great deal of evidence that the atom, ion and molecule are much more complex than is generally supposed, the atom being a rather complicated system in itself, containing electrons or "atoms of electricity" revolving in orbits of their own. These electrons possess electro-kinetic and electro-potential energy. The energy of ions and molecules may then consist of several different forms besides the energy of the external field due to charged ions. Unless we know all about the energy in the two cases we cannot arbitrarily say that the energy of "charged" ions must be greater than "uncharged" molecules or even atoms. We could never be justified in such an assertion until we had shown the sum total of all the energy in a molecule or uncharged atom must necessarily be less than the energies of the charged ion. We must take into account the electropotential and electro-kinetic energies of the electrons, the mutual energies of the different electrons, the mutual energies of the electrons and atoms, and the mutual energy of the atoms in the molecule besides the energy of the external field.

The author concludes that the ionic theory for solutions has proven very fruitful, although he does not maintain that it is perfect or not incapable of improvement. Since no better theory has been offered as a substitute it should be allowed to stand until something obviously better is offered in its place. If it has not been proven to be true, certainly it has not been shown to be impossible. It does not necessarily violate either the conservation of energy or any other established theory of physics.

In the discussion which followed, Mr. C. J. Reed said that he did not find anything in the paper he would criticize in connection with his former criticisms. He claimed that what Dr. Parsons had offered was not the dissociation theory, but Parson's own theory. Messrs. G. L. Cabot, J. W. Richards, E. F. Roeber and R. Gahl also participated in the discussion, the latter two defending Parsons' paper and the dissociation theory. Dr. Gahl expressed the opinion that if one accepts the electron theory, some difficulties which might be found in the conception of the ion would disappear.

Aluminium Electrolytic Condenser.

A paper on this subject by Mr. C. I. Zimmerman was read, in the absence of the author, by Mr. A. B. Marvin.

After some brief remarks on the well-known property of the aluminium electrode, which permits a current to pass in one direction but not in the other, and a brief discussion of non-symmetrical cells in general, the author gave some notes on the film which causes the peculiar behavior of the aluminium electrode. This film, which is probably an oxide, has a thickness which could be measured by interference phenomena and was found to be between 0.000005 and 0.00005 cm. Its dielectric constant has also been determined and found to be pretty large (Mr. Mott gave afterwards, in the discussion, its value as 10).

The author then gave an account of experiments which he has made with the aluminium electrolytic rectifier, which is essentially a combination of two aluminium electrodes, while the electrolytic rectifier consists of one aluminium electrode and one iron electrode. As electrolyte a solution is used which allows the film to be reformed by electrolytic action. The author pointed out that a constant charge is held at all times in the condenser when connected to an alternating-current circuit, and gave the experimental proofs of the presence of the charge. The condenser action was shown to be due to energy variations alone, and not to coulomb variations. The aluminium electrolytic condenser was then briefly compared with tinfoil condensers and the losses in the electrolytic condenser which were classified into resistance losses, leakage losses, and film losses were briefly discussed. They increase about proportionally to the frequency of the current. On account of the electrolytic reformation of the film, any punctures which occur in the film, are automatically repaired. While in one case the author succeeded in constructing a condenser which could be used up to 1250 volts, electrolytic condensers should not be used at a higher voltage than about 150. The author obtained an efficiency as high as 97 per cent, but when operating a condenser at not more than 110 volts in continuous operation, one may expect an efficiency of 95 per cent. The capacity is about one-quarter to one-half microfarad per square inch of surface of a single electrode.

This paper was the last read in the Friday session, and its discussion was taken up on Saturday morning. Mr. W. R. Mott referred to the well-known Graetz rectifier arrangement which enables one to utilize both the positive and negative half waves of an alternating current for rectifying purposes and stated that it was patented in the United States in 1891 by Mr. T. D. Bottome (September 1891). He exhibited samples of the aluminium film on glass. While having the color of aluminium for reflected light, it is quite transparent. Not sufficient material of the film has yet been collected to enable one to make an accurate analysis. The leakage loss is due to small points in which the film is ruptured. He made some suggestions as to the effect of previous treatment; for in-

stance, it would be interesting to use a condenser first at 20 volts, then at 100 volts, and then again at 20 volts, and to see whether the old results are again obtained. He also spoke of the use of the electrolytic condenser as a phase splitter. Mr. E. E. F. Creighton referred to the dielectric constant of the film which is much higher than that of other solids, and asked whether it was not, perhaps, due to gases occluded in the film. Dr. K. E. Guthe stated that he had actually fund gases in the film (ELECTROCHEMICAL INDUSTRY, vol I., 1902, page 48), but Mr. Mott thought that the experimental arrangement of Dr. Guthe did not show conclusively that the gases given off did really come from the film. Dr. Guthe remarked, however, that after the gases had been removed the resistance of the film was very much reduced. Dr. J. W. Richards asked whether this might not point to the fact that when operated under a high atmospheric pressure the condenser would be more effective. Dr. R. Gahl said he had used aluminium cells as condensers in measurements of the resistance of cells, but had found them to be not constant. Mr. Mott stated that the leakage current, while depending upon the nature of the electrolyte, is very small at low voltages in certain solutions like phosphate, etc., but when one comes near the critical voltage the leakage current becomes large.

STUDY OF THE ELECTRIC ARC.

A highly interesting paper on this subject was presented by Dr. WILLIAM S. WEEDON, of the General Electric Company. He has studied the so-called flame arcs between metallic electrodes. This class, as distinguished from the crater arc of the ordinary carbon lamp, is especially interesting, since it is possible to follow the changes in the character of the light as the conditions are altered.

One very important problem is the amount of material which is transported during the running of the arc. In air it is quite large for most materials. The rate of waste of carbon is diminished by running "enclosed" or in an atmosphere of carbon monoxide. The question is how much material is necessarily transported at a given current density, voltage and arc length and whether there is any law for arcs corresponding to Faraday's law for solutions. From the investigations of the author of the copper arc in air, the copper arc in hydrogen, the iron arc in hydrogen, and the carbon arc in hydrogen, it is quite evident that this is not the case. In some cases there is a tendency for the anode to gain in weight rather than lose, and the loss of material is very much smaller than would correspond to Faraday's law. With the copper arc in hydrogen and with water-cooled electrodes, there was transferred only about 1/1500 of the Faraday equivalent for solutions.

It seems that oxidation, or combination with the surrounding gas, is not absolutely necessary for the production of a luminous arc, but such combination facilitates its formation. With regard to the amount of material fed to the arc, there is apparently a tendency for the arc to ionize the surrounding atmosphere if there is not enough material vaporized from the electrode. If much heat is developed, more is vaporized than is employed in transporting the current. Between these two extremes, both the atmosphere and the electrode vapor are ionized. It is therefore hardly possible to make measurements which will give figures comparable to Faraday's equivalents. It appears that there is a slow gradation from the spark discharge to the true arc, passing through the intermediate stage where both kinds of discharge are present. The main distinction, therefore, between the arc and the spark discharge is that in the former vaporized material from the electrode or electrodes undergoes most of the ionization which takes place, while in the latter the surrounding atmosphere suffers most of the ionization.

The structure of metallic arcs in air is in general as follows: The very middle path is luminous, but the light is derived from the outer mantle and most frequently form that portion of the outer mantle next the inner path. In the carbon arc the outer mantle is not well defined, owing to the fact that the product of combustion is gaseous. It seems probable that the inner non-luminous path is in a way comparable to the Crookes dark space. The explanation given for the presence of the latter is that a large number of negative ions present have too great a velocity to ionize the atoms with which they collide, but that further along the tube, when their force has been diminished by collision, ionization may take place. Where this occurs, light is given off. In the arc the inner path may be caused by the fact that the negative ions, in very great number, are moving rapidly toward the anode and producing ionization only where the force has been sufficiently diminished by collision, viz., on the sides of the inner path.

From a number of experiments it appears that the cathode determines the character of the arc, but there are other instances which distinctly contradict such a general statement. The author gave some interesting notes on the explanation of the phenomena in the arc on the basis of the electron theory, but frankly stated that we are not yet enabled to give a complete and consistent theory. He finally stated that the character of the light is not determined simply by the heated particles present in the arc. There certainly may be heated particles present which are not active in giving off light. It does not appear altogether out of the question to associate the light derived from the cathode with negatively electrified particles, and that derived from the anode with positively electrified particles. There seems no necessity for making a more complicated assumption, although it must be admitted that one may be possible. It is perfectly conceivable, for instance, that under certain circumstances, the vapor from the anode may be ionized by negative ions, and consequently should be associated with the latter. The author's experiments with the magnetite-copper arc do not seem, however, to be in accord with this view.

In the discussion of Dr. Weedon's paper, Mr. E. E. F. Creighton referred to the influence of the wave form upon the voltaic arc, and exhibited several oscillograph curves. In his experiments he had a series of arc lamps operated at 2300 volts with 66 amperes, the wave form of the alternating arc being affected by the resistance, inductance, the length of the arc and the nature of the carbon. Mr. Hering thought, to get a strictly uniform current one should use the current from a storage battery. Dr. Weedon had used the current from a dynamo which is always somewhat fluctuating. Messrs. J. W. Richards, W. H. Browne also participated in the discussion.

COPPER VOLTAMETER.

Dr. ISAAC ADAMS and Prof. BARRY MACNUTT then presented a paper on some phenomena observed in connection with a copper voltameter which was read by Prof. MacNutt. In the course of a determination of the intensity of the horizontal component of the earth field by means of a tangent galvanometer the authors used a copper voltameter and observed some peculiar irregularities. When the reversals took place through the galvanometer they observed certain irregularities in the current which might be expressed as though polarization increased while the cell is open. Another point is the resolution of the deposited copper. Allowance must be made for both factors. The reversals should not be made too often, not oftener than say every five minutes, then the irregularities in the current are negligible; further, the amount of redissolved copper must be taken into account. If these precautions are taken, the copper voltameter is suitable for exact measurements. In the discussion, Mr. Hering remarked that in measurements requiring such a great accuracy (to the fourth decimal point) the copper voltameter should better not be used at all. Prof. MacNutt replied that if the proper precautions are taken, consistent results are obtained.

ELECTROLYTIC IRON.

A highly interesting paper by Prof. C. F. BURGESS and Mr. CARL HAMBUECHEN, of the University of Wisconsin, was then

presented. In the absence of the authors, it was read by Prof. J. W. Richards. While electric furnace processes have recently attracted much attention in their application to the metallurgy of iron and steel, it seems that the electrolytic effect has not been considered seriously, as it is commonly held that the difficulties inherent in the deposition of iron are such as to preclude its playing an important part in the industrial electrometallurgy of this element. The authors have, however, found that electrolytic iron can be produced in such quantities and at such cost as to make it a material of commercial as well as of scientific importance should sufficient demand for it arise.

A survey of available literature on the subject of electrolytic iron leads naturally to the assumption that its deposition is difficult to accomplish, and that there are few solutions from which it can be deposited. Moreover, it has been held that a satisfactory quality of deposit can be attained only by the use of very low current densities and an exceedingly slow rate of deposition. Practically the only uses to which electrolytic iron has been put are in the so-called "steel facing" of dies and electrotypes, and as a material for investigating the properties of the pure metal.

The hardness of electrolytic iron which makes it especially suited to the facing of electrotypes is due to the occluded hydrogen which is practically the only impurity present. In fact the very term "electrolytic iron" is commonly assumed to be synonymous with "pure iron." In just what manner the hydrogen is held by the metal is a matter of doubt, it being claimed by some that it is simply condensed, and by others that it forms a definite hydride. Such iron may contain this gas in quantities equal to several hundred times the volume of

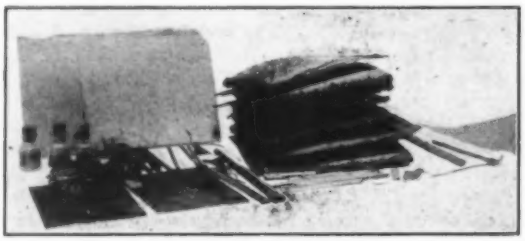


FIG. 3. ELECTROLYTIC IRON.

the metal, and it can be almost entirely freed from it by heating.

Something over two years ago the authors undertook an experimental investigation of the conditions suitable for electrolytically depositing iron, and this work has proceeded almost without interruption since that time. The primary object of the investigation was to produce, if possible, pure iron in such quantities and at such cost as to make it an available material for further inquiry into its properties. The preliminary work consisted in testing the various electrolyte materials which had been suggested previously, and from these the most promising were selected as the basis for further trials. A large number of iron salts were used and the effects of variations of density of solutions, current densities, temperature, agitation of electrolyte and various other factors were noted. As a result of such observations, ferrous sulphate, with a certain percentage of ammonium sulphate, was chosen as affording the most satisfactory results, and the process, as it is now being operated on a small experimental scale, is described as follows: The electrolyte consists of ferrous and ammonium sulphates; the current density at the cathode is 6 to 10 amperes per square foot of cathode surface, and at the anode slightly less; the e. m. f. for each cell is slightly under one volt; the temperature of electrolyte is about 30° C.; the anodes consist of ordinary grades of wrought iron and steel; the starting-sheets for the cathodes are of thin sheet-iron, previously cleaned of rust and steel.

One of the most serious difficulties encountered was in obtaining a thick deposit of iron. While there is a considerable range of conditions under which iron can be deposited uniformly and densely for a few hours, or perhaps for a few days, it was almost always found that the surface would become so rough or pitted, or that such a rapid treeing would take place, or that the deposit would curl up to such a degree that it was necessary to discontinue the experiment and start a new one under different conditions. But improvements have been gradually effected until at the present time it is possible to continue the run four weeks without replacing the cathodes. At the end of such time the cathode reaches an average thickness of about three-quarters of an inch, and the surface is so rough and nodular that it is not considered advisable to carry the deposition further.

The current efficiency of deposition is very closely 100 per cent; that is, there is a deposition of about one gram per ampere hour. The e. m. f. being one volt, gives about 2.2 pounds of iron per kilowatt-hour. Since all the factors which go to make up the cost of large scale production cannot be accurately determined from a small scale experiment, the authors are unable to state from the investigations what would be the cost of working on an industrial scale. For the past six months three tanks have been maintained in almost continuous operation, these tanks having the dimensions 8 inches wide x 13 inches long x 15 inches deep, and containing two anodes and one cathode. The finished cathodes from these tanks weigh about 20 pounds and constitute, perhaps, the largest pieces of electrolytic iron which have, up to the present time, been produced. The total amount of the material which has been produced from all experiments is about one-half ton.

A run of two months' duration was made to determine the extent of the deterioration of the electrolyte, resulting in the conclusion that the solution can be kept in good working condition with little trouble or expense. It would appear therefore that the cost of refining, aside from fixed charges on plant, and with power at $30 per kilowatt-year, would be under one-half cent per pound of iron, thus placing it not greatly in excess of the cost of refining copper.

Even with these figures realized, whether or not electrolytic iron can be profitably produced depends upon the uses which can be made of the refined metal. These in turn depend upon its properties, the most striking of which is its purity. Although the work was directed toward the production of electrolytic iron in a dense and massive condition, rather than in a high degree of purity, analyses which have been made show the purity to be in excess of 99.9 per cent. Not a trace of carbon was detected, and silicon, manganese and other impurities commonly found in iron appear to be absent. The only impurity which has been detected is hydrogen, which is present in appreciable quantities in the metal as taken from the electrolytic tanks. This gaseous element in its physical or chemical combination with iron influences, in a most striking manner, the physical properties of the metal. The hydrogen can be driven off almost completely, if not entirely, by heating to a white heat, the evolution commencing at a temperature below 100° C., and becoming rapid at a temperature below a red heat. Electrolytic iron heated in a Thomson welder or even in a Bunsen burner has been observed to give off hydrogen so rapidly that it ignites and continues to burn after removing the source of heat, presenting an appearance similar to that which would be produced by dipping the iron in alcohol and igniting it. The metal containing the hydrogen is so hard that it can be filed or sawed only with difficulty, and is so brittle that it is readily shattered by a sharp blow from a hammer. After the expulsion of the gas it becomes softer, and after having been raised to a welding temperature it assumes properties of malleability and toughness similar to those of Swedish iron.

The iron, when heated in a forge fire, can be readily welded and forged into any desired shape, and various test samples

were made in this way. During such working, however, impurities are introduced, analyses invariably showing the presence of a very small percentage of carbon. The cathodes, three-fourths of an inch in thickness, have a surface so rough that they cannot be rolled satisfactorily into sheets, though it is possible that improvements can yet be made in this respect which will enable smooth surfaces to be obtained. The deposit adheres so loosely to the starting sheets that it can be removed readily.

A considerable amount of work has been expended in the attempt to melt electrolytic iron without at the same time introducing impurities. The difficulties that lie in the way of doing this, however, are great on account of the high temperature necessary, and the affinity which the iron at such temperature has for many of the elements. The melting temperature of the pure iron seems to lie closely to that of platinum, though actual values have not as yet been determined from lack of suitable measuring instruments. Various forms of electric furnaces have been constructed for this purpose, a furnace of the inductor type appearing to be the most suitable for preventing the introduction of carbon. Results which have been somewhat satisfactory have been obtained by heating a molten electrolyte between graphite electrodes to a suitable temperature and introducing the metal into such molten bath. The metal thus produced is tough and malleable, while it also has a fracture of coarse crystalline nature. The affinity which the iron has for carbon is shown by the fact that it can be readily melted in a graphite crucible, while a silica crucible heated to a considerably higher degree melts before the iron in it begins to flow. The absorption of the carbon in the former case produces a fusible alloy of iron.

Experiments have shown that the hysteresis, permeability, and electrolytic resistance of electrolytic iron are greatly influenced by the amount of hydrogen in it. An iron ring was deposited in such form that a hysteresis and permeability loop could be determined by the Ewing method. It was found that by heating in boiling water the hysteresis was lowered several hundred per cent. By further heating in an oil bath to 200° the value was decreased still further, but to a smaller extent than in the first heating, and upon attempting to heat it to 500° the ring broke and the experiment was therefore interrupted. Certain samples of forged iron have shown permeability values equalling or even exceeding those of the highest permeability standard samples of Swedish iron. Other samples prepared under apparently identical conditions showed much poorer results, so that it is impossible as yet to draw definite conclusions as to the magnetic properties of electrolytic iron.

It having been shown that it is possible for electrolytic iron to be produced at a small cost, the question naturally rises as to what uses there may be for it. The first suggestion which naturally presents itself is that on account of its purity it would serve as a basis for investigating the properties of iron and its alloys. Investigations having for their object the determination of the influence of various elements alloyed with iron as regards its electrical properties have been unsatisfactory on account of the presence of other impurities which modify or mask the effect of the element which it is desired to study. Starting with the pure iron, therefore, alloys of a predetermined and definit composition can be produced, thus making such investigations of greater simplicity. Unless the difficulties encountered in the working of electrolytic iron on account of its roughness offer too serious an objection, it should compete favorably with the purer grades of commercial iron which are used for various purposes and which sell for three cents and upwards per pound.

Electrolytic iron naturally offers the means of manufacturing chemically pure iron compounds and for standardizing solutions in the analytical chemical laboratory. The electrolytic iron, in addition to its purity, has the advantage for the purpose just mentioned of rapidly dissolving in an acid solution. A test which was made to determine the rate at which electrolytic iron and iron wire sold as chemically pure for standardizing purposes dissolves, showed a ratio of one to twelve in favor of the former. By reason of the brittleness imparted by the occluded hydrogen, it can be readily broken up into grains of a desired size, and even reduced to a fine powder. Summing up their work thus far done, the authors say that it is possible to obtain electrolytic iron in large quantities, and at a reasonable cost, and that, therefore, iron should be added to the list of metals to which the process of electrolytic refining can be applied satisfactorily. Such iron possesses a high degree of purity, though just how closely it approaches absolute purity can be shown only by spectroscopic analyses or by other methods which have not yet been made use of.

In the discussion of the paper Mr. Woolsey McA. Johnson said that he made some small scale experiments concerning the electrolytic refining of iron and had used the same electrolyte as the authors, with an addition of an organic acid. The organic acid acts as a reservoir and always keeps the concentration of the hydrogen ions constant. To melt pure iron he suggests the following apparatus. Take Acheson graphite bars, six-inch diameter, machine out to crucible form and use pure Al_2O_3, mixed with water glass, specific gravity 1.10, brasquing. He advocated the usefulness of making experimental researches on a somewhat larger scale from the start, as has been done in this case by the authors. Mr. Carl Hering spoke of another problem, that of the reduction of iron from ores by electrolytic methods. In a preliminary investigation of this problem he has reached the result that this would be too expensive for two reasons. First, the number and area of tanks required for depositing as many tons of iron as are now produced by one of our large furnaces would be enormous. Secondly, the energy required would be large. In the blast furnace the heat of combustion of the reducing carbon is added to the process; a somewhat similar effect could, perhaps, be produced in electrolysis by using something like a depolarizer, but he did not think that there is any hope for industrial electrolytic reduction of iron from ores. He then asked why cast iron cannot be used for the anodes in the Burgess and Hambuechen refining process instead of wrought iron and steel, which are far more expensive. Messrs. Johnson and Richards thought that cast iron would be unsuitable on account of quick disintegration, so that the amount of anode scrap would be excessive.

The Reduction Temperature of Zinc Oxide.

A paper on this subject was presented by Mr. Woolsey McA. Johnson, of the Lanyon Zinc Co., who remarked that it is axiomatic to say that any determination which will give definitely any of the physical constants of a chemical reaction will be beneficial in working that reaction on a large metallurgical scale. In the reduction of zinc oxide by solid carbon, a reaction which absorbs considerable heat, a certain thermochemical potential must be reached before any chemical change takes place.

Before this point is reached the chemical potential of the reverse reaction is greater than that of the reduction. The difference of potential is a function of the difference of temperature between the "reaction temperature," and the temperature of the reacting bodies. If the function is a linear one, and we have the reduction temperature at 1050° C., the reaction velocity, when the reacting bodies are at 1100° C., will be five times as fast as the reaction velocity when the reacting bodies are 1060° C.

It is easy to say that to determine the reaction temperature, all that is necessary is to heat up the components of the reaction with a pyrometer in them and observe the temperature at which the reaction starts, but as anyone who has had any experience in the matter knows, it is found in practice that the lag of the reading in the pyrometer behind the reaction and the temperature gradient of the charge give often very discordant results.

A practical cell, to determine the reduction temperature of zinc oxide accurately and quickly, should conform to the following conditions. The cell should be made of a refractory material not reacting with the substance to be tested. The cell should be tight that the products of the reaction may escape through one small hole, so as to make a bright and sensitive flame. The cell should conduct heat to the charge and to the pyrometer so easily that the pyrometer junction and the charge are always at nearly the same temperature.

After some experimenting with fire-clay and fire-clay mixed with graphite, the substance which the author found to fill best these conditions was solid Acheson graphite bars, such as are suitable for the electrolysis of zinc chloride. These round bars make almost a perfect crucible if machined out on a lathe.

The cell which was finally adopted is described as follows: A four-inch round Acheson electrode is cut off in pieces four inches long. A two and one-half inch hole is drilled in this round bar on a lathe, its axis being the axis of the bar. A thread is cut in the top of the hole to receive the threaded cover, also made of graphite. In the lower part of the cell a three-fourths inch hole is drilled to receive the pyrometer, one-half inch of graphite being left between the charge and the pyrometer. All this work is done accurately by machine tools, for, as is well known, it is possible to machine Acheson graphite accurately. Just below the line of the charge a one-fourth inch or three-eighths inch hole is drilled. This hole is tapped to receive a threaded iron or graphite pipe, which is used in case the indicator is carbon monoxide gas and not zinc. When the zinc flame is used as an indicator, this pipe is not screwed into the hole.

In the experiments made by the author in connection with Mr. W. Chapman, the pyrometer used was the usual platinum-palladium platinum couple with the galvanometer reading directly in degrees Centigrade. A broken outside porcelain tube was used in preference to a new porcelain tube, because the radiation by the graphite on the junction gives very quickly the temperature of the cell to the pyrometer junction.

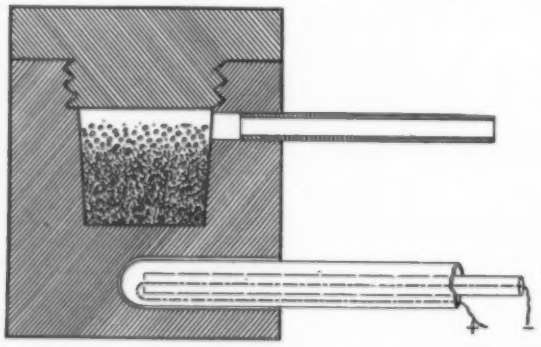


FIG. 4. APPARATUS FOR MEASURING THE REDUCTION TEMPERATURE.

The procedure in determining the reduction temperature is as follows: Equal parts of the material to be reduced are mixed with the reduction material filling the cavity to about one-half its height. A little of the coarse reducing material is sprinkled over the top. The cover is next screwed on, and the cell put in the furnace. The furnace is a specially built experimental reverberatory furnace, fired with natural gas and equipped with a heater for the air, and with checkerwork to make a quick combustion. A ten-inch graduated dial on the handle of the gas valve allows accurate adjustment of the flow of gas and a damper allows accurate adjustment of the flow of the air. By a proper regulation of the temperature and flow of air and flow of gas it is possible to have a radiant flame consisting of hot particles of carbon of almost any temperature from 900° to 1700° C. This radiant flame heats the cell without undue oxidation of the graphite. The degree of regulation can be seen in the curve of experiment No. 10, where in the second determination the temperature increased as a linear function of the time by 30° in 30 minutes.

The pyrometer is next inserted into the cell and clamped to a wrought iron support outside the furnace. It is then connected to a permanent circuit leading to the galvanometer. The galvanometer is placed on a pier made of bricks, laid in cement about 6 feet from the furnace. The door of the furnace is partially closed with a block of fire-brick.

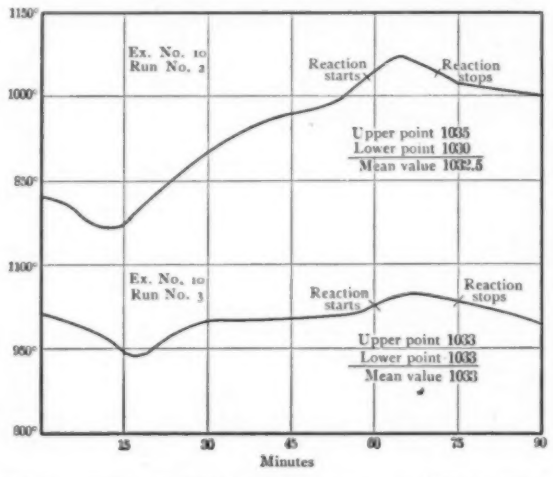


FIG. 5. DETERMINATION OF REDUCTION TEMPERATURES.

The temperature is first raised quickly and a rough determination made of the temperature at which the snakey flame is given off. The cell is cooled down and the temperature at which the zinc ceases to be given off is taken. The mean of these two values is then 10° to 15° off the true value. The last one is usually fairly close to the final value. Now the gas is turned on again and the temperature of the cell raised very slightly at the suspected temperature. While one observer reads the pyrometer and regulates the gas the other watches the small hole in the cell for the zinc flame. When the reaction starts the observer reading the pyrometer is notified and the point where the reaction starts is marked down on the curve which is plotted during the determination. The temperature of the cell is raised 5° or 10° to insure this is the real reaction and not a chance reaction due to impurities in the mixture. If the reaction is the real reaction and not a false reaction, the evolution of zinc and carbon monoxide increases rapidly with the temperature. The temperature is then lowered slightly and the point at which the reaction stops is noted down. Two or three determinations are made and the mean of the means taken as the true value. The means usually agree within 2° or 3° with each other. If the values are not concordant the reason is to be found in an inhomogeneous charge. Thus in one experiment the preliminary value was found to be 1020° C. The author accordingly raised on the first determination the temperature quite rapidly to 1020° C. and then slowly. The reaction started at 1035° and stopped at 1030° C., giving as a mean 1032.5° C. On the second trial the reaction started at 1033° C., and stopped at 1033° C., giving a mean of 1033° C. and a mean of means also of 1033° C. They have made even closer determinations than these, but of course this would be due to chance, and the above is a little bit better than the average.

A glance at Table I. brings out quite clearly what has been the somewhat indefinite opinion of zinc smelters from practical observation, namely, that the temperature of roasting effects the ease of reduction, and that different reducing materials have different rates of reduction. The idea of the

author is that the reduction of zinc oxide is caused by the very slight vapor of solid carbon and the slight dissociation pressure of zinc oxide tending to break up the zinc oxide into zinc and free oxygen. It is easy to imagine the effect of heat in making a denser and more stable configuration of the atoms in the molecule on reducing these vapor pressures. It can even

TABLE I.—REACTION TEMPERATURES.

Material to be Reduced.	Reducing Material.	Corrected Mean of Means.
C. P. zinc oxide	1100° charcoal	1022° C.
C. P. zinc oxide, calcined at 1300° C	"	1025
C. P. zinc oxide	Soft coke	1029
C. P. zinc oxide calcined at 1100° C	"	1048
C. P. zinc oxide, calcined at 1300° C	"	1061
C. P. zinc oxide	Graphite turning	1084
Roasted Colorado ore	Soft coke	1029
Roasted Joplin ore	"	1073
Roasted Joplin ore	Very soft, 600° charcoal	1033
Roasted Joplin ore	1100° charcoal	1059
Roasted Colorado ore	1500° charcoal	1073
Joplin ore	"	1087
Joplin ore	Graphite turning	1116
Colorado ore	"	1120
B. P. Cadmium	"	756
C. P. Cadmium oxide, made by wet method	600° charcoal	767
C. P. Cadmium oxide, made by wet method	1100° coke	813
C. P. Cadmium oxide, made by wet method	Graphite turning	849
Zinc Sulfid, from Joplin	Cast iron filings	1187

Same coke used in all experiments made in 48 hours in bee-hive ovens. 87 per cent fixed carbon; 1 per cent volatile.

Joplin ore from bin roasted at about 1060 degs. C.

Colorado ore from bin roasted at 900 to 950 degs. C.

Charcoal was made by heating Southern pine in large covered crucible, until volatile matter ceased evolving.

be conceived how the change is an electrochemical one in its nature, and that the electrons play a very material roll. These results and conceptions tend to show that the primary reduction of zinc oxide by carbon is not caused by carbon monoxide, although there is no doubt that carbon monoxide does tend to increase the rate of reduction after the primary reduction is once started. The above, however, is more an opinion gained by intuition from seeing many experiments on the reduction of zinc rather than any rigid deduction from the experiments.

In the discussion which followed the reading of Mr. Johnson's paper, Mr. G. L. Cabot asked whether experiments had been made on the reduction of zinc oxide by the direct action of natural gas. Mr. Johnson replied that while several attempts had ben made in this direction by various experimenters, satisfactory results have not yet been obtained. Dr. J. W. Richards expressed himself in favor of Mr. Johnson's hypothesis that the carbon vapor plays a very important part in the reduction and referred to the analogous process of reducing silicon. Mr. C. J. Reed thought that carbon vapor does not exist at temperatures such as those used in the experiments as otherwise the manufacture of an incandescent lamp would be impossible. Mr. Johnson replied that only a very small amount of carbon vapor needs to be assumed, and that the blackening of the globe of an incandescent lamp proves the existence of carbon vapor, but Mr. Cabot suggested that this was rather an effect of the current than of the heat. Mr. Johnson pointed out what a fine material Acheson graphite is and that nearly everything may be made from it. He proposed the use of an apparatus like that used in his experiments, for distilling cadmium for its employment as a material in standard cells.

MISCELLANEOUS.

Mr. S. S. Sadtler, the newly-elected secretary, then showed some samples of porous diaphragms which may be ground down to any convenient thickness, so that their resistance is very small. They may be made up in any form useful for experimental or commercial purposes. We intend to refer to the same in a future issue.

Mr. C. J. Reed, the retiring secretary, read a letter from Dr. W. D. Bancroft, calling the attention of the Society to the "Relative Decimal Card Index for Electrochemical Interests" of Mr. L. VOEGE in Zurich, Switzerland. The co-operation of the members of the society was requested. A paper by Mr. Voege on this subject had been sent, but was not read at the meeting on account of limitations of time. After its publication in the Transactions of the Society, it will be noticed in these columns.

The following three papers were read by title, but not discussed at the meeting. Advance sheets, however, were distributed from which the following abstracts have been prepared.

ELECTROLYTIC PREPARATION OF WHITE LEAD.

A paper by Mr. C. F. CARRIER, JR., gives an account of some laboratory observations on the electrolytic preparation of white lead. The original patents of Luckow specified that a 1½ per cent solution of a mixture of 90 parts $NaClO_3$ and 10 parts Na_2CO_3 should be electrolyzed between a hard-lead cathode and a soft-lead anode, CO_2, and water being added as required. It was shown, however, by LeBlanc and Bindschedler, and Isenburg, that true white lead could only be produced when the CO_2 is greatly diluted with air. The most satisfactory proportion was found to be 1 part CO_2 to about 20 parts of air. In this case, however, the absorption of the CO_2 by the electrolyte is by no means complete, and provision for reuse must be made, or great loss will ensue. The question now arose as to whether basic lead carbonate of the desired composition could be produced by some process differing essentially from that of Luckow.

As the subject of the experiments of the author the process of Richard and Roepper (U. S. P. 644,779) was chosen. It consists in electrolyzing a 5 per cent solution of a mixture of 1 part Na_2SO_3 and 40 parts CH_3COONa with lead electrodes, a small quantity of some nitrate being added to aid the solution of the anode. With a current density of 100 to 200 ampere per m^2, the acetic acid anions are supposed to be decomposed at the anode, yielding CO_2 to precipitate the white lead, the necessary admixture of hydroxide being formed by action of the sulphite.

The author describes a series of experiments which he has made under different conditions and some of the main results of his observations are as follows. The use of copper cathodes reduces the voltage between the cell terminals. With a current density of 100 amperes, or more, per m^2, the anode dissolves irregularly, "pitting" badly. With a solution containing enough hydroxide to precipitate white lead, spongy lead is deposited on the cathode, even in those experiments in which the product was largely carbonate. To prevent a large deposit of lead on the cathode, it would seem necessary to have a permanent store of CO_3 ions in the solution, thus making Na_2CO_3 or other soluble carbonate an essential constituent of the electrolyte. The solution effect of nitrates on lead, when added to the acetate solution, seems to have a higher efficiency than chlorate alone. The tendency of lead to deposit on the cathode is less with a more dilute solution. To procure basic carbonate of the proper composition requires a fineness of regulation of CO_2 dilution beyond the command of the apparatus which were at the author's disposition.

OSMOTIC PRESSURE AND ALTERNATING CURRENT.

A paper by Mr. WILLIAM H. DAVIS records some peculiar observations made in the course of experiments to perfect a method of recovery of cyanogen from the double salts of a cyanide solution. A direct current was first used, but it was soon found that a division of the compound sought (KCN) was the result, and that correction could not be made by placing the anode in a porous cup, for the alkali and acid radicles were constantly being separated by the current effect. Therefore, if a solution of alkali, say caustic soda, was contained in the porous cup, the sodium radical would pass out proportional to the entering cyanogen, and if an excess of caustic soda was maintained, even by washing the anode, a poly-

merization of the cyanogen would occur in sufficient amount to make the process valueless for the work at hand.

Experiments were then made with alternating current, and it was found that the desired results were obtained together with precipitation of the basic metals when an excess of free alkali was present. The determinations were made by the usual Lebig method ($AgNO_3$) and it was found that by no other method could the cyanide content be raised higher. In the case of foul solutions the cyanide was in many cases raised 0.5 of one per cent. The author refers to the report of the director of the Mint on the production of precious metals in the United States in 1903, pages 99 to 101.

The author then studied the theoretical side of the problem and found that "an alternating current would raise the osmotic pressure of a solution concentrated so that complete dissociation was not present."

The experiment is described as follows: A porous cup holding about 200 cc. was rendered semi-permeable with copper-ferrocyanide and the walls so adjusted that the cup would maintain a hydrostatic pressure of one cm. above the water level outside the cup. A rubber stopper with two holes was then placed securely in the cup, through one of which holes a glass tube was inserted, one square mm. in cross-section, reaching within 1 mm. of the bottom of the cup, and through the other hole another tube was inserted reaching only to the bottom of the stopper; the hole was then sealed with sealing wax and placed in a beaker of distilled water, wires of platinum were placed in the tubes, which served as electrodes, and these were connected to a switchboard. Through the tube reaching to the bottom of the cup a 10 per cent solution of sodium-acetate was led into the cup until the height in the tubes indicated 10 cm. above the water level outside the cup, and then the apparatus was allowed to stand for twenty-four hours. At the end of this time the solution stood 1 cm. above the water level, and then 2 amperes of alternating current were sent through the solution. No changes were made excepting to close the switch. In five seconds the solution rose to 5 cm. and would not go higher during the next thirty seconds. The current was then turned off and the solution fell to the initial height in about twenty minutes. The current was again turned on and the same results followed, and this was gone through with perhaps twenty times during the week or ten days following. The current was from a three-phase generator of the usual type, working at sixty cycles per second; one leg of the circuit was used and the current was controlled by a bank of incandescent lamps connected in multiple.

Manufacture of Ferro-Nickel from Pyrrhotite.

A paper by Mr. Ernst A. Sjöstedt, chief metallurgist of the Consolidated Lake Superior Power Co., gives an account of electric smelting experiments made at Sault Ste. Marie for the manufacture of ferro-nickel from pyrrhotite. An account of his process, and an illustrated description of his furnace have already been given in our April number, page 153 and 154, to which the reader may be referred.* The present paper of the author contains some supplementary information. The furnace lining is made of magnesia brick, the only material which he has found to withstand the heat and chemical action between the charge and the lining. These bricks have the following composition:

SiO_2	4.41 per cent
Al_2O_3	23.07 "
CaO	9.40 "
MgO	63.12 "

He gives the following estimate of cost for a furnace of 300 to 500 hp., in which 200 hp. would probably suffice for obtaining a gross ton of ferro-nickel per twenty-four hours. At a rate of $10.00 per hp.-year for power, $5.00 per ton for the ore, $5.50 per ton for coke, and $2.50 per ton for limestone, the cost items for the manufacture of 1 ton of ferro-nickel pig in the electric furnace at this place would probably have been as follows:

2 tons partly roasted pyrrhotite at $5	$10.00
500 pounds coke, at $5.50	1.37
1.5 ton limestone fines, at $3.00	4.50
Labor and salaries	2.50
Electrodes and repairs	2.50
Power, 200 hp., at $10.00	5.50
Total cost per ton metal	$26.37

The value of this product—a ferro-nickel pig with 3 per cent nickel contents—should be that of the nickel contained in the metal plus that of the pig iron; so that, if we assume the value of nickel at 30 cents per pound, and pig iron at $14.00 per ton, the product would be worth ($60 \times \$.30 = \$18.00 + \$13.57$ or) $31.57—showing a profit of over $5.00 per ton of metal produced.

In the following we give an alphabetical list of all members and guests who registered at the meeting:

Lawrence Addicks, Perth Amboy, N. J.; Sydney W. Ashe, New York; C. Baskerville, Chapel Hill, N. C.; F. M. Becket, Niagara Falls, N. Y.; Philander Betts, Washington, D. C.; Mrs. S. S. Birdsell, Boston, Mass.; Henry S. Blackmore, Mount Vernon, N. Y.; H. B. Brooks, Washington, D. C.; William Hand Browne, Jr., New York; E. A. Byrnes, Washington, D. C.; Mrs. E. A. Byrnes, Washington, D. D.; G. L. Cabot, Boston, Mass.; H. S. Carhart, Ann Arbor, Mich.; C. R. Cary, Baltimore, Md.; G. B. Chorpening, Clarksburg, W. Va.; George B. Cock, Philadelphia, Pa.; E. E. F. Creighton, Pittsfield, Mass.; Mrs. C. H. Cromwell, Savannah, Ga.; F. P. Dewey, Lanier Heights, Washington, D. C.; William Dreyfus, New York; C. W. Fairbank, Washington, D. C.; F. A. J. Fitzgerald, Niagara Falls, N. Y.; S. P. Franchot, Niagara Falls, N. Y.; R. Gahl, Philadelphia, Pa.; Mrs. R. Gahl, Philadelphia, Pa.; F. W. Grover, Washington, D. C.; Karl E. Guthe, Washington, D. C.; Aaron Hale, Boston, Mass.; Carl Hering, Philadelphia, Pa.; F. W. Higgins, Niagara Falls, N. Y.; B. H. Hite, Morgantown, W. Va.; H. L. Hodgkins, Washington, D. C.; F. A. Holton, Washington, D. C.; N. M. Hopkins, Washington, D. C.; William Smith Horry, Niagara Falls, N. Y.; Mrs. W. S. Horry, New York; E. J. Hutchinson, Cincinnati, O.; H. W. Jenkins, New Orleans, La.; W. McA. Johnson, Iola, Kan.; Edward Keller, Baltimore, Md.; E. B. LeMare, Lathkil, Rusholme, Manchester, Eng.; M. G. Lloyd, Washington, D. C.; H. J. Lucke, Washington, D. C.; Mrs. H. J. Lucke, Washington, D. C.; Barry MacNutt, Bethlehem, Pa.; A. B. Marvin, Jr., Washington, D. C.; H. T. Matthew, New York; G. E. Middleton, Washington, D. C.; Jefferson Middleton, Washington, D. C.; Mrs. J. Middleton, Washington, D. C.; Mrs. William B. Moncine, Washington, D. C.; W. R. Mott, Ithaca, N. Y.; E. H. Mullin, New York; C M. Nissen, Washington, D. C.; William A. Noyes, Baltimore, Md.; R. J. Nunn, Savannah, Ga.; Raymond Outwater, Washington, D. C.; Henry Noel Potter, New York; E. J. Prindle, Washington, D. C.; Samuel Reber, Washington, D. C.; C. J. Reed, Philadelphia, Pa.; Clarence E. Reid, Washington, D. C.; J. W. Richards, Bethlehem, Pa.; Mrs. J. W. Richards, Bethlehem, Pa.; William Richards, Bethlehem, Pa.; A. G. Rodgers, Niagara Falls, N. Y.; E. F. Roeber, New York; S. S. Sadtler, Philadelphia, Pa.; G. E. Schmitt, New York; G. P. Scholl, Philadelphia, Pa.; Mrs. Johanna Abels Scholl, Philadelphia, Pa.; A. W. Smith, Cleveland, O.; W. O. Snelling, Washington, D. C.; H. Stokes, Penn Yan, N. Y.; E. Stütz, New York; E. R. Taylor, Penn Yan, N. Y.; Mrs. E. R. Taylor, Penn Yan, N. Y.; C. P. Townsend, Washington, D. C.; Mrs. C. P. Townsend, Washington, D. C.; G. L. Townsend, Washington, D. C.; Miss Sue R. Truestall, Washington, D. C.; F. von Kügelgen, Holcomb Rock, Va.; C. D. Vreeland, Upper Montclair; Charles W. Waidner, Washington, D. C.; William S. Weedon, Schenectady, N. Y.; Mrs. William S. Weedon, Schenectady, N. Y.; H. W. Wiley, Washington, D. C.; Frank A. Wolff, Jr., Washington, D. C.; Charles C. Wright, Washington, D. C.

The Electric Furnace in Metallurgy.—An interesting lecture on this subject was recently delivered by M. R. Petaval, of Paris, at the Chemical Institute of Nancy. It has been published as a bulletin of the Société Industrielle de l' Est. The author emphasizes that the electric furnace is no longer to be considered as a commercial possibility, but as an accomplished fact, and gives some data on commercial plants in which electric furnaces are used in connection with steel, zinc, nickel, ferro-silicon and ferro-chromium. The largest part of the lecture deals with steel processes and some suggestions are quite interesting. We will abstract it in our next issue.

* See also the letter in the correspondence columns of our present issue.

ELECTROCHEMISTRY AT THE UNIVERSITY OF WISCONSIN.*

BY PROF. CHARLES F. BURGESS.

While the birth of electrochemistry antedates that of the other branches of electrical engineering, it is only within comparatively recent years that its importance has increased to such a degree that special courses of study devoted particularly to this branch of science and technology have been introduced in our universities and technical school. The renewed interest in electrical phenomena in their relation to chemical phenomena has resulted in and has been further promoted by notable scientific discoveries, the introduction of new theories, the establishment of a new school of physical chemistry, and in many profitable technical applications of electricity to the production of elements and compounds some of which had been unknown hitherto.

Though electrochemistry has had its main growth within the past two decades; its development has been so rapid that it now constitutes an acknowledged branch of engineering, which, by requiring men of special training, has led to the introduction of new courses of study in some of study in some of the engineering colleges.

The University of Wisconsin was among the first in this country to take up this line of work, an electrochemical course of three hours per week for one term having been given by the Electrical Engineering Department in 1894. Shortly thereafter the facilities were notably increased through the establishment by Dr. Louis Kahlenberg of a course in physical chemistry, dealing with the modern views of the German school of electrochemists, which his studies in Europe made him most qualified to teach.

Three years ago a four years' course of study in applied electrochemistry was added to the various courses offered by the College of Engineering, and the interest which has been shown by the students and the growing demand for the graduates show that this addition was fully warranted. It is the purpose of this course to afford a training in the fundamental principles of physics, chemistry and engineering, such as may fit its graduates for entering industrial pursuits in chemical, mechanical, electrical and electrochemical engineering where a co-ordination of chemistry with the more strictly engineering branches is necessary.

The course in applied electrochemistry as here given is co-ordinate with the electrical engineering course, differing from it mainly in including a considerable proportion of chemical work throughout the four years. Such chemical work includes courses in general chemistry, analytical, organic, physical chemistry and electrochemistry.

FIG. 1.—ELECTROLYTIC TANKS.

The work for the first year includes German or French, English, algebra, descriptive geometry, trigonometry, analytical geometry, mechanical drawing, shop work and general chemistry.

For the second year technical German or French, analytical and descriptive geometry, calculus, physics, kinematics, mechanics, shop work and analytical chemistry are required.

The list for the third year includes mechanics, precision of measurements, applied electromagnetism, materials of construction, advanced analytical chemistry and assaying, chemical preparations, physical chemistry and electives.

For the senior year the studies are alternating currents, steam engineering, testing of materials of construction, electrical installations, electric lighting and power transmission,

*At the request of the editor of the ELECTROCHEMICAL INDUSTRY this description of the work and equipment in electrochemistry at the University of Wisconsin has been submitted in the belief that what our universities are doing for the promotion of electrochemistry may be of interest as representing a certain phase of electrochemical work in this country.

contracts, chemical machinery, organic chemistry, applied electrochemistry, thesis and electives.

The junior work in physical chemistry deals with the fundamental principles and modern theories of electrochemistry and includes laboratory practice in the making of various measurements and determinations.

The course in chemical preparations and industrial chemistry is designed with the view to impressing upon the student the matter of costs. It is almost entirely a laboratory course and each student makes on a fairly good scale various typical chemical products. He is required to give a statement of the efficiency of the process, materials consumed, materials produced, waste products, methods of procedure on a large scale, the machinery and apparatus necessary, and an estimate of labor and power. In this manner it is sought to impress the economic questions which enter into chemical work.

LOUIS KAHLENBERG.

The study of chemical machinery is a class-room course dealing with the various machines and appliances used in chemical industries together with a consideration of various processes, such as drying, evaporation, distillation, etc.

The work in applied electrochemistry consists of class work, supplemented by laboratory exercises relating to the application of the laws and principles of electrochemistry as applied to various industrial purposes, including the deposition of metals in plating, electrotyping and refining, primary and secondary batteries, and the various electrochemical products and processes which have become of technical importance.

The course of study here outlined has certain limitations which it is the purpose to overcome in the future as rapidly as facilities may permit. One of the most serious difficulties in designing a course in applied electrochemistry is the necessity of crowding into four years all the studies which seem essential and desirable to satisfactorily equip the graduate for entering professional work. For best results, therefore, it seems desirable to extend the work one or two years above the regulation four years. It is the purpose to leave the election of a certain proportion of the work to the individual students' preferences, and among the electives from which choice may be made to advantage are the following studies given in various departments of the university: Mineralogy, geology, assaying, electrolysis and electrosynthesis of organic compounds, courses in physical chemistry, thermal chemistry, electrical testing, electricity in mining and quarrying, central station design, management and estimates, photometry, hydraulics, gas engines, compressed air, and masonry construction.

Laboratory work plays an important part in the teaching of many of the courses, and this together with the thesis work, upon which considerable stress is laid, develops the thinking powers and the abilities of independent observation and investigation.

Two parties of students and instructors are organized each year to go upon inspection trips on which visits are made to manufacturing plants and large engineering enterprises of the various industrial centers. Each student is expected to accompany two of these parties during the last two years of his course.

At the physical chemistry seminary which holds a meeting one evening each week, and which is attended by the advanced and graduate students who elect to take part, original articles of importance appearing in the scientific publications are reported upon and studied in detail.

The local section of the American Institute of Electrical Engineers, which holds frequent meetings and takes up the papers presented before the general society enables the students to follow electrical developments, and electrochemical matters are discussed in similar meetings of the local section of the American Electrochemical Society.

Physical Chemistry Laboratory.

The work in physical chemistry is under the direction of Dr. Louis Kahlenberg, assisted by Mr. F. L. Shinn. The physical chemistry laboratory occupies the basement of the present chemical building, the size of which is about 50 feet x 150 feet. The construction of a large new chemical building, which is shortly to be begun, will greatly increase the laboratory space devoted to this work. The present space includes one large general laboratory which will accommodate about thirty students. A balance room and two dark rooms are connected to this general laboratory. Another room, which is supplied with current from a series of storage cells and a 110-volt dynamo is devoted exclusively to electrolytic work. The equipment consists of ampere meters and voltmeters, potentiometers, electrometers, carefully calibrated resistances, etc., which may be required for special work. The department owns a complete outfit for the measurement of dielectric constants, including Nernst's apparatus, and that of Drude in their latest forms.

Three other laboratories are devoted to research work, and are equipped with chemical tables, hoods, water, gas and electricity and otherwise equipped for handling various classes of work, as occasion may require.

The laboratory owns a Pulfrich refractometer of the latest pattern, with all accessories, also spectroscopes, polariscopes, chemometers, and apparatus for measuring critical pressures and volumes. A very complete set of thermometers of various kinds, calorimeters for the determination of specific heats, latent heats and heats of chemical reaction are available as well as the ordinary apparatus for measuring electrical conductivities, differences of potential, balances, thermostats, etc., which are necessary for physical chemistry work.

CHARLES F. BURGESS.

To provide for the extensive researches undertaken in the field of non-aqueous solutions there is a large collection of all typical solvents of organic and inorganic character.

The general students in physical chemistry take all the work outlined in a laboratory manual, such as that of Ostwald-Luther. In electrochemistry the work includes the determination of electrical conductivities of single potentials and of potentials of various galvanic chains, decomposition points, verification of Faraday's law, influence of the e. m. f., current density, temperature and chemical nature of the electrolyte upon the character of electrolytic deposits. The determination of dielectric constants, and the preparation of typical chemical substances by electrolysis also constitutes part of the work. Instruction is also given in the testing and opera-

tion of batteries, and construction of standard cells and normal electrodes.

For thesis and advanced work, special lines of investigation are pursued, such being determined by the purpose of the student and the facilities afforded by the laboratory. Funds are available for obtaining additional apparatus needed for special work which may be in progress.

At the present time the lines of investigation upon which work is being done include vapor tensions, osmosis, decomposition potentials, e. m. f. of galvanic chains in solvents other than water, thermal changes accompanying chemical reactions which take place in non-aqueous solvents, and measurements of dielectric constants and chemical equilibrium.

On the conductivity of a large number of non-aqueous solutions in various solvents, prominent among which is a research on the conductivity of solutions in liquid hydrocyanic acid.

The toxic action of various solutions and of metals upon plants and animals, and the taste of aqueous solutions were investigated.

All of these various investigations had for their special object the inquiry into the nature of solutions, and were primarily undertaken to verify present theories of solutions, and the theory of electrolytic dissociation. As these researches progressed, however, it became evident from the facts established that our present theories are inadequate. Ralizing this

FIG. 2.—APPLIED ELECTROCHEMISTRY LABORATORY.

A. Lecture Room, with projection lantern. B. Workshop. C. Office and Analytical Room. D. Electrodepositing Room. 1. Storage Batteries. 2. Electrolytic Vats. 3. Cleaning Tanks. 4. Motor-Generator. 5. Switchboard. 6. Centrifugal Separator. 7. Rotary Ball Mill. 8. Compressed Air Receiver. E. Grinding and Polishing Room. F. Drying Room. G. Store Room. H. General Electrolytic Laboratory. 1. General Switchboard. 2. Work Tables. 3. Hood. 4. Reagent Stand. 5-6. Instrument Cases. 7. Filter Press. 8. Electrolytic Bench. I. Electric Furnace Room. J. Storage Battery Room. K, L, M. Research Rooms. N. General Laboratory.

Investigations of the past few years which have yielded results of interest and importance include the following:

Dielectric constants of solvents and solutions.

Potentials of galvanic cells containing solvents other than water.

Electrolysis in non-aqueous solutions and the validity of Faraday's law in such solutions.

Instantaneous chemical reactions in non-aqueous, non-conducting solutions.

Specific and latent heats of evaporation, and on a new method of determining the same.

On the relation between boiling points and freezing points and electrical conductivity in aqueous and non-aqueous solutions, especially as viewed in the light of the theory of electrolytic dissociation.

fact, further researches are being conducted with the express purpose of placing our theoretical notions of solutions, osmosis, and electrical conduction upon a better and more rational basis.

APPLIED ELECTROCHEMISTRY LABORATORY.

The work in applied electrochemistry is under the direction of Prof. C. F. Burgess, assisted by Mr. Carl Hambuechen and Mr. J. G. Zimmerman. The laboratory occupies the second floor of the electrical laboratories, the plan being shown in the accompanying drawing. The portion of the floor which includes the research rooms is at present in process of construction, and will practically double the space available for electrochemical work.

The present space includes a large plating room, rooms for polishing and grinding, chemical analysis and weighing, work

shop, drying room, general laboratory, high-tension room, research laboratories, a storage battery room, and store rooms, one of which is not shown on the plan. On the first floor adjoining the dynamo room is the electric furnace laboratory.

The plating room equipment comprises a motor-generator having a capacity of 300 amperes at a pressure up to 10 volts on the low pressure side; twelve large lead lined, wood and enamel lined tanks of a capacity of from 30 to 60 gallons capacity, hot water, lye and cleaning tanks. Plating and refining solutions for copper, nickel and zinc are maintained continually, and the other tanks are used for experimental work on various other solutions. A rheostat is connected to each tank, and voltmeters and ampere meters are installed so that by a simple switching arrangement they may be connected to any of the tank terminals. The equipment in the electrodepositing department was obtained chiefly from the Hanson & Van Winkle Co., and is similar to that installed by them in technical plants.

The grinding and polishing room contains two high-speed lathes, driven by an electric motor. By means of the above, equipment instruction is given in electroplating, electrotyping, and the refining and recovery of metals.

The equipment of the general laboratory includes eight specially designed switchboards for varying and regulating the current used in small electrolytic experiments, together with a large number of rheostats, electrolytic tanks, stirring devices, instruments for measuring current, e. m. f. and resistance. A considerable proportion of the apparatus has been designed and constructed in the laboratory, and to the valuable assistance of the Mechanism department of the College of Engineering, in charge of Mr. E. H. J. Lorenz, many of the special instruments and devices are due. The equipment also includes balances, filter presses, centrifugal drying machine, a rotary ball mill and other grinding mills, a vacuum drying oven, etc. A system of compressed air furnishes at various outlets around the laboratory air at a pressure of 60 pounds to the square inch.

Electrical energy is furnished by the dynamo laboratory and by the city lighting and power circuits. Both alternating and direct currents are available, the former in quantities up to several hundred amperes at a pressure of 110 volts, and the latter up to 1000 amperes at the same pressure. By means of a 20-kw. high-tension transformer, pressures are available in values up to 60,000 volts.

In the electric furnace room is a switchboard connected to a Bullock direct-current generator, capable of delivering 1000 amperes at a pressure of 110 volts. This current is regulated and controlled for furnace work by a water-pipe rheostat illustrated in accompanying photograph. It consists of ten lengths of ¼-inch wrought iron pipe capable of carrying about 250 amperes without excessive heating with no water circulating, and a maximum capacity considerably above 1000 amperes with the water turned on. The current is regulated in ten steps by opening or closing the switches, which short-circuit the various sections as may be required. A self-acting switch protects the generator and engine from damage by sudden short-circuits. Water is supplied to each of the lengths of pipe through a two-foot length of rubber hose, such material being necessary to prevent short circuits between the consecutive lengths of pipe.

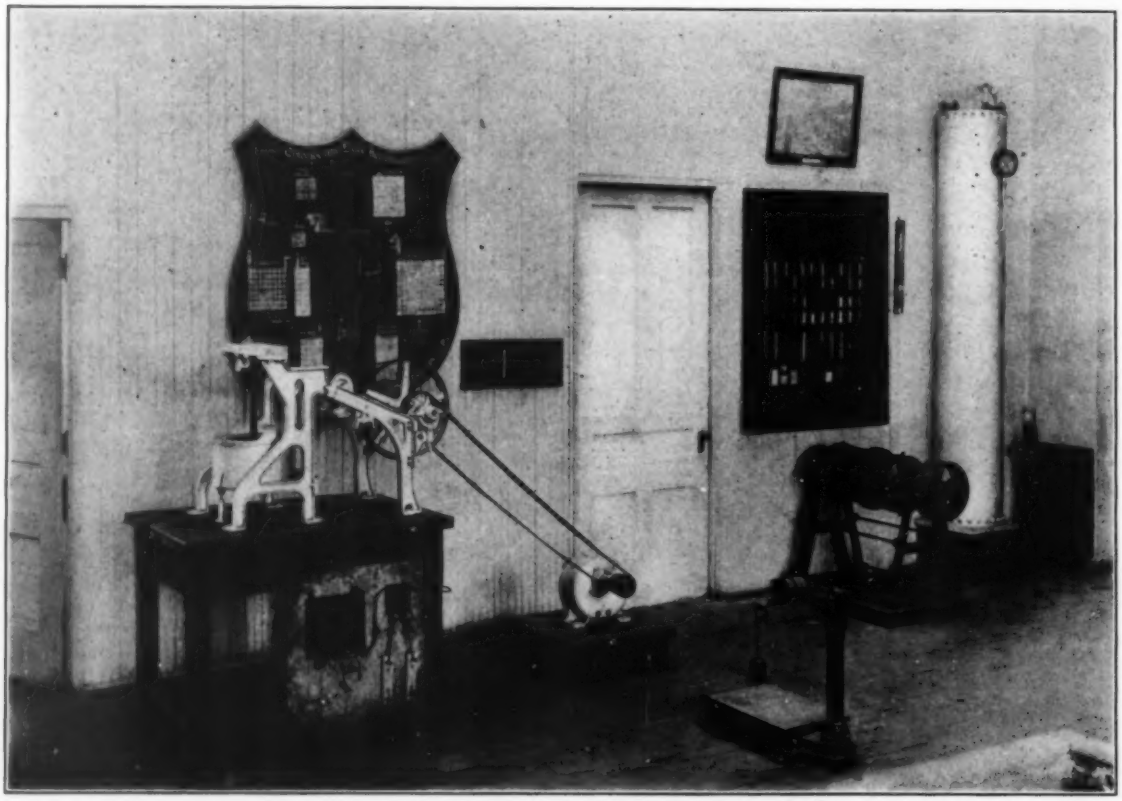


FIG. 3.—CENTRIFUGAL SEPARATOR AND GRINDING MILL.

A 10-kw. auxiliary rheostat made by the Wirt Electric Co., of Philadelphia, consisting of cast-iron strips supported on an iron frame and mounted on rollers serves for handling currents below 150 amperes.

Alternating current for high temperature work is obtained from alternators in the electrical laboratory and from the city power circuit and is at present available in quantities up

to 40 kw., although a 200 kw. alternator is to be installed, and in operation within a few months. For adapting the alternating pressures to the various uses required in furnace work a 20-kw. transformer was specially designed for this purpose and constructed in the laboratory. By means of switching arrangements it may receive its full capacity at pressures ranging from 110 to 220 volts, and the switches which connect the subdivided secondaries in series or parallel pressures

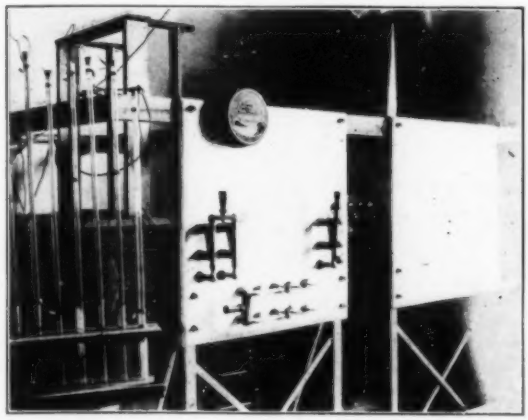


FIG. 4.—50,000-VOLT TRANSFORMER AND SWITCHBOARD.

from 15 to 200 volts may be delivered to the furnaces. A high-pressure coil, capable of delivering 20 amperes at 1000 volts is used for operating high resistance electric furnaces where the material under treatment is a high resistance substance such as molten silica.

Various small electric furnaces of the Moissan and Borchers types which have been imported are installed and used for various high temperature small scale experiments. Most

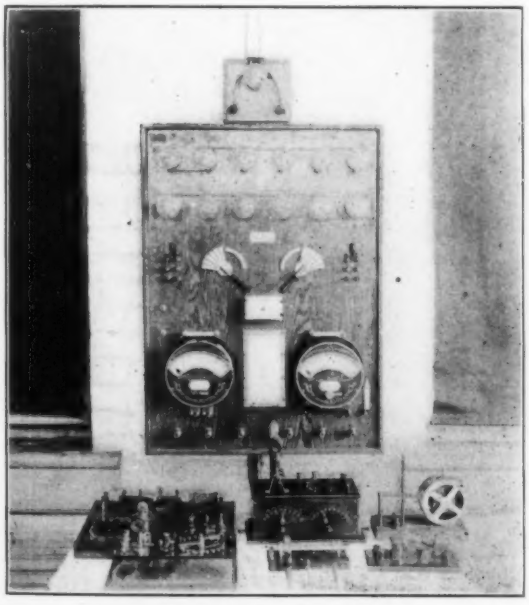


FIG. 5.—INSTRUMENTS MADE IN LABORATORY.

of the furnaces used have been, however, constructed in the laboratory, various refractory materials, such as magnesite and silica fire-bricks, magnesia, lime, silica, etc., being employed in such construction.

To adapt the electrode supports to the construction of various types of furnaces necessary for a variety of experimental work, two sets of electrode supports have been designed and constructed, and which have given excellent satisfaction. These are capable of holding carbon or graphite rods up to 2 inches in diameter, and have a capacity for handling currents up to 1000 amperes, the terminal blocks being provided

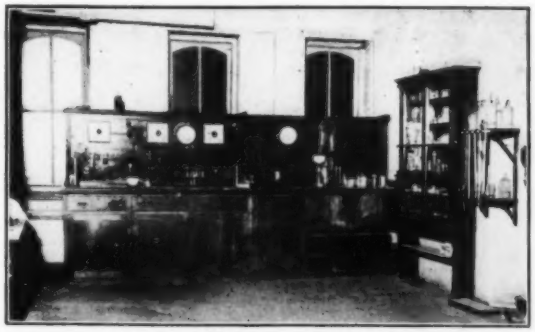


FIG. 6.—ELECTROLYTIC WORK TABLES.

with water-cooling pipes. The horizontal type is capable of vertical adjustment by means of a slot and lock-nut and the electrodes may be set at any desired angle through 90°. The electrodes are adjustable backward and forward by means of lever arms. The vertical electrode supports are an adaptation inches of the vertical type suggested by Mr. R. S. Hutton, of Owens College, Manchester, England.

The work tables of the furnace room are constructed of wood frames supporting a top of concrete and cement three inches thick. This form of top was adopted to reduce dan-

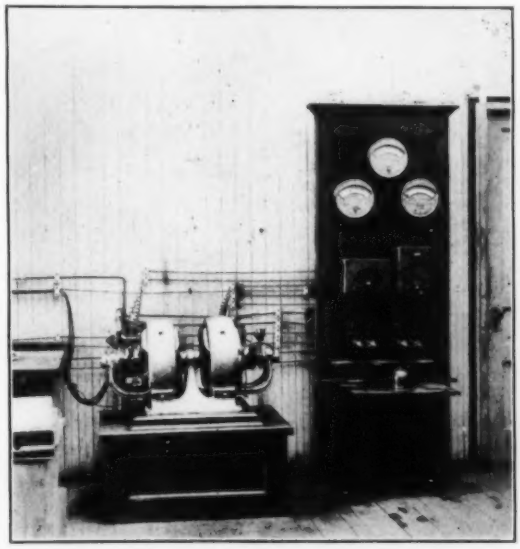


FIG. 7.—MOTOR-GENERATOR AND SWITCHBOARD.

ger from fire, but experience has shown that in an experimental room of this sort the entire absence of wood work is desirable.

For conducting high temperature and electrolytic work various new forms of apparatus and methods have been devised, some of which are referred to in the following paragraphs.

In measuring single electrolytic potentials the well-known "calomel" electrode is employed, its e. m. f. being assumed as 0.56 volt, and where convenience and rapidity requires the use of cadmium or other suitable metal, the single values of such are determined in terms of the "calomel" standard.

For measuring small electric potentials with a high degree of accuracy a Leeds potentiometer is available, but for ordinary purposes where a degree of accuracy consistent with unavoidable experimental error is attained, a simpler and much cheaper potentiometer outfit has been designed and constructed in the laboratory which permits an accuracy within one-tenth of one per cent. Two forms of this potentiometer outfit are illustrated in cut, showing apparatus constructed

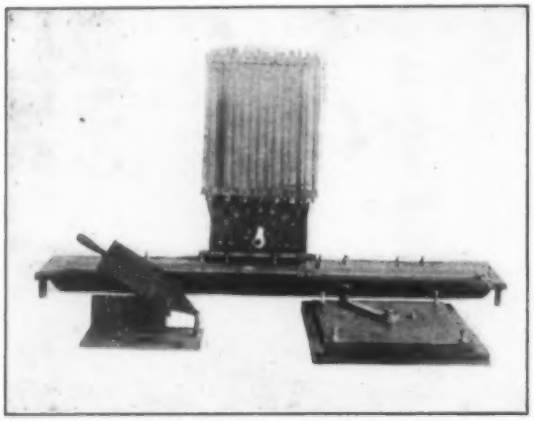


FIG. 8.—SPECIAL CARBON RHEOSTATS.

in the laboratory. It consists of 1000 ohms subdivided into ten 10-ohm coils in series, with nine 100-ohm coils, each of these steps being connected to suitable contact terminale to which radial arms make contact. This is an adaptation of the

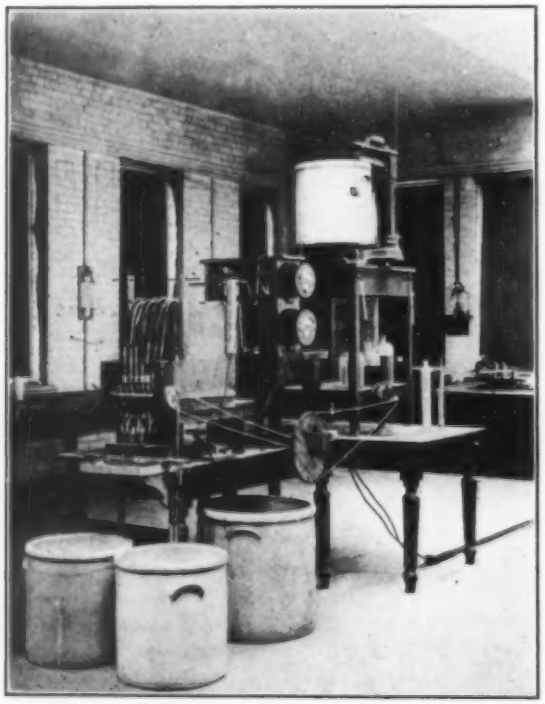


FIG. 9.—EXPERIMENTAL APPARATUS FOR THE PRODUCTION OF CHROME YELLOW.

Ostwald potentiometer, with radial adjustment arms which increase the convenience of working, and in addition there is supplied a 9000-ohm coil, which can be placed in series with the 1000 ohms, increasing the range of measurement ten times. By means of this outfit, potentials varying from less than 0.001 volt to over 100 volts can be measured with an accuracy of one-tenth of one per cent. It is used for the calibration of ampere meters and voltmeters, the measurement of e. m. fs., and resistances by the fall of potential method. It has proved especially suited to the determination

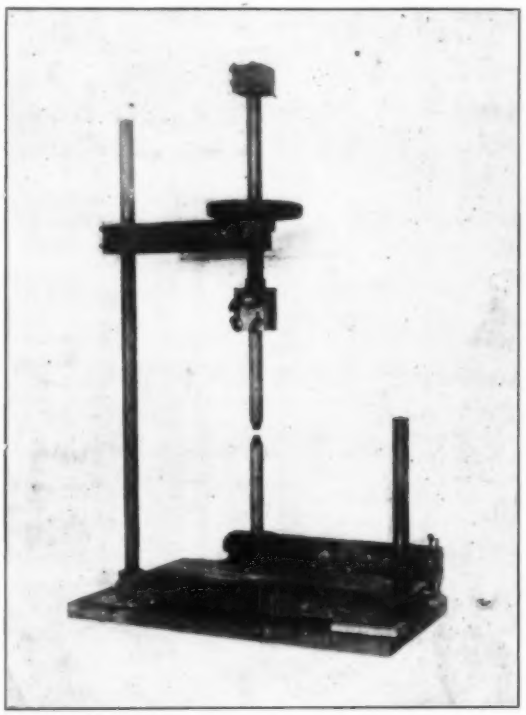


FIG. 10.—VERTICAL ELECTRODE SUPPORTS.

of resistances of very high value, above 100,000 megohms, such as are encountered in the determination of insulation resistances.

The indicating instrument used in connection with this potentiometer is, for ordinary purposes, a horizontal portable galvanometer or millivoltmeter, but where these cannot be used satisfactorily a portable capillary electrometer is employed. The form of electrometer which has been found espe-

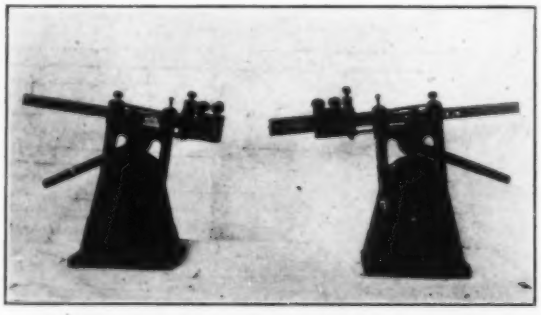


FIG. 11.—HORIZONTAL ELECTRODE SUPPORTS.

cially adaptable is a modification of the well-known Lippmann instrument, and is illustrated in Fig. 16. It is so arranged that there is no possibility of spilling the electrolyte. The position of the meniscus is determined by means of a small microscope fitted with a micrometer eye-piece, and the portability of the instrument and the freedom from vibration influences may be judged from the fact that the meniscus

may be adjusted upon the scale of the eye-piece and after shipment by express may be found ready for immediate use without readjustent. A portable instrument of this sort was constructed with a sensitiveness of 0.00002 volt, and used for several months in a study of the changes of e. m. f. which are set up by iron under various conditions of strain.

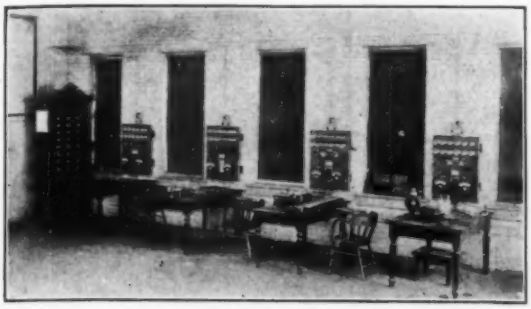


FIG. 12.—ELECTROLYTIC WORK TABLES.

For the measurement of electrolyte resistances the well-known methods are employed. A method which has been found of great convenience, overcoming the various sources of error in a degree sufficient to meet commercial requirements is illustrated in Fig. 15, where an ordinary voltmeter is the only indicating instrument employed. The method of operation consists in placing the electrolytic resistance in a rectangular trough of such length as to furnish between the terminal electrodes a resistance having a suitable proportion to the resistance of the voltmeter. The measurement consists in connecting the cell terminals in series with the voltmeter to a 100-volt or other convenient source of pressure. By closing the switch S to (a) the voltmeter gives the total

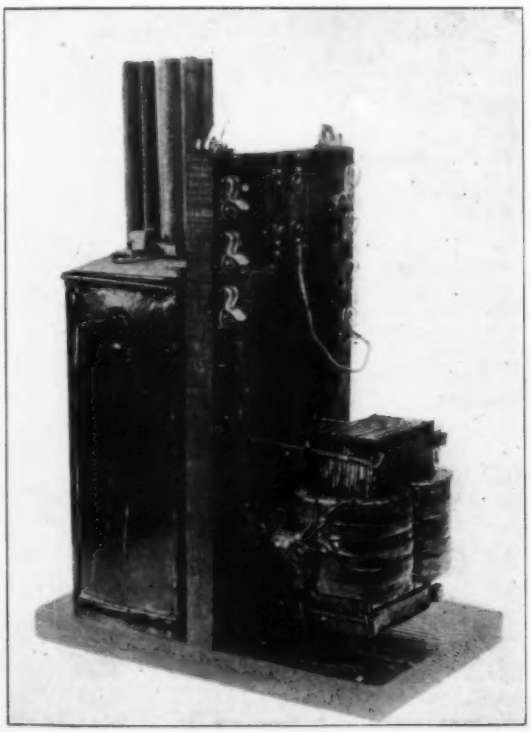


FIG. 13.—AQUEOUS RECTIFIER.

pressure E, and upon opening the switch the resistance of the electrolyte is thrown in series with the voltmeter, thereby reducing the reading to a value E′. By applying the following formula the resistance of the electrolyte R′ is derived, R being the resistance of the voltmeter.

$$R' = R \frac{E-E'}{E'}$$

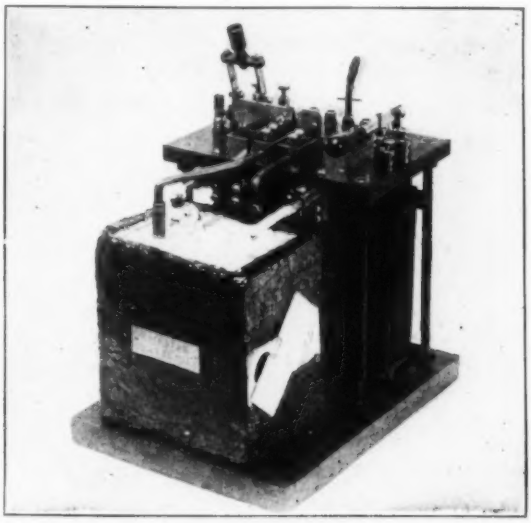


FIG. 14.—RECTIFIER WITH FUSED ELECTROLYTE.

This method is especially applicable for the rapid determination of the resistances of the earth, or any high resistance electrolytic conducting material.

Where it becomes desirable to measure the specific resist-

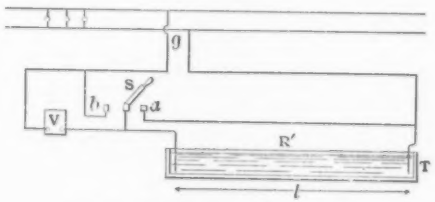


FIG. 15.—MEASURING RESISTANCES.

ance of an electrolyte by simply immersing the measuring apparatus in the solution, as a hydrometer would be used for determining the density, a tube containing the electrodes, as illustrated in Fig. 17, is employed. The measurement can be made by means of a voltmeter, as previously described, or by other suitable means.

An important part of the equipment of an electrochemical laboratory consists in rheostats for adjustment of current values. Some rheostats which have been designed and constructed to meet the special requirements of this laboratory are shown in an accompanying illustration. To obtain a small step-by-step adjustment of current for electrolytic work from a 110-volt source of supply six wall lamp resistance boards are installed. These permit of range of current from 0.1 ampere to 6 amperes in fifty steps, each board being supplied with an ammeter and voltmeter.

Carbon rods mounted on an iron frame and protected by an iron screen constitute a cheap and satisfactory form of rheostat for large volume, low pressure currents. A special form of rheostat for use in the testing of one or two storage cells is also shown. It is a combination of switch

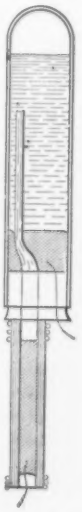


FIG. 16.

and rheostat, the side bearing springs being divided into a number of sections faced with carbon blocks about ¼-inch thick. The blade of the switch consists of a metal frame holding strips of carbon, and the two opposite sides of the switch constitute the terminals of the resistance. The resistance is adjusted by the sliding contact to the exact value desired, this being done by closing the knife of the switch to the desired degree. This form of switch has the advantages of cheapness, gradual adjustment, and large current-carrying capacity.

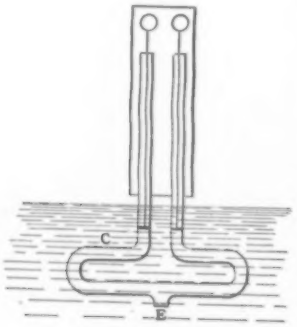


FIG. 17.—MEASURING SPECIFIC RESISTANCE.

In an electroplating room one of the difficulties with rheostats commonly used is the corroding of the contacts which therefore require frequent attention. The wall rheostats illustrated in the photograph from the electrolytic depositing room were designed to overcome this difficulty by enclosing the contact points behind a glass cover. These rheostats have now been in use for five years without giving the least trouble from poor contacts.

A high pressure rheostat of low current carrying capacity, and having a sliding contact adjustment, is made by cutting a circular band in a slate or stone slab and filling this with a mixture of graphite, pumice-stone and a binding material, the relative proportion of the material being determined by the degree of resistance and current carrying capacity required. A considerable number of such rheostats are in use and are found to be durable and cheap, and capable of being heated to about 150° C.

The work of the first semester in the applied electrochemistry laboratory consists in performing such experiments as will give an idea of the various methods of making electrolytic measurements of resistance and potentials, of the oxidation and reduction and other electrolytic effects of the current; experiments illustrating the applicability of Faraday's law to the deposition of metals and production of various chemical reactions. The various details connected with the deposition of nickel, copper and zinc and other metals for plating purposes are studied together with the methods of

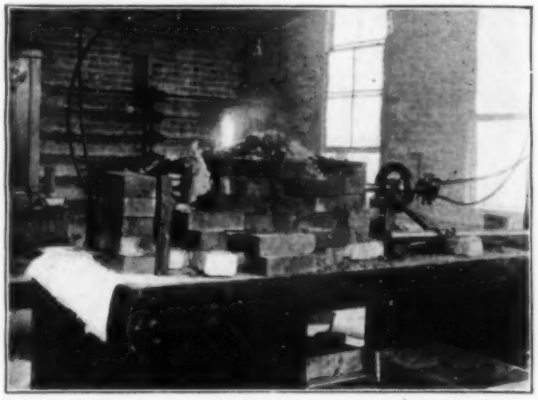


FIG. 18.—EXPERIMENTAL ELECTRIC FURNACE.

cleaning and preparing the surfaces both before and after receiving the deposits. The effect of current density, temperature, composition, density and circulation of the electrolyte as regards the influence on the character of the metal deposit are illustrated by a set of experiments. Batteries, both primary and secondary, are subjected to tests of efficiency, resistance, polarization, etc.

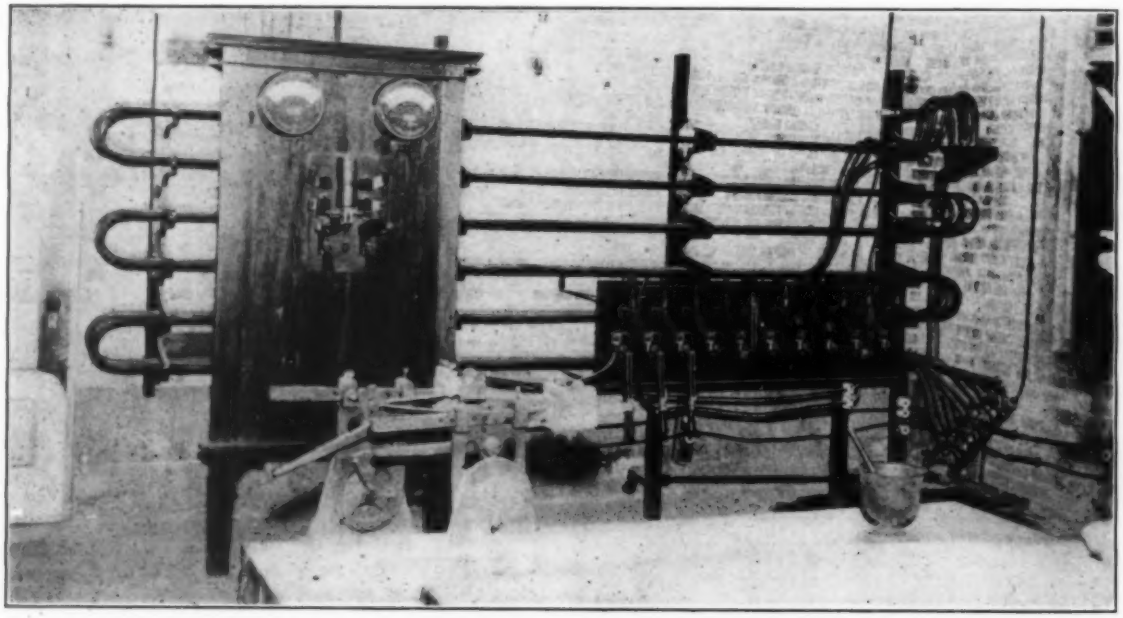


FIG. 19.—RHEOSTAT FOR ELECTRIC FURNACES.

The work during the second semester deals with the operation and study on a miniature scale of various technical applications of electrolysis and high temperature work. This includes the production of hypochlorites, chlorates by the electrolysis of salt solutions; also the production of alkali, chlorine, pigments, metallic sodium, calcium carbide, carborundum, silicon, graphite, aluminium, magnesium, and various other materials of a similar kind.

The thesis work and the graduate study in applied electrochemistry covers largely the study of special problems. While it consists mostly in laboratory investigation it includes also

an examination of the literature bearing on the subject, facilities for which are available in the University and State Historical library, one of the most complete libraries in the country, having complete files of most of the important scientific and engineering publications in English, German and French, together with complete sets of the United States, British and Canadian patents.

Among the investigations which are now under way are the following. A study of the electrolytic refining of iron has been in progress for over two years, and with results which indicate that chemically pure iron can be produced as simply and as cheaply as is the case with copper. About one-half

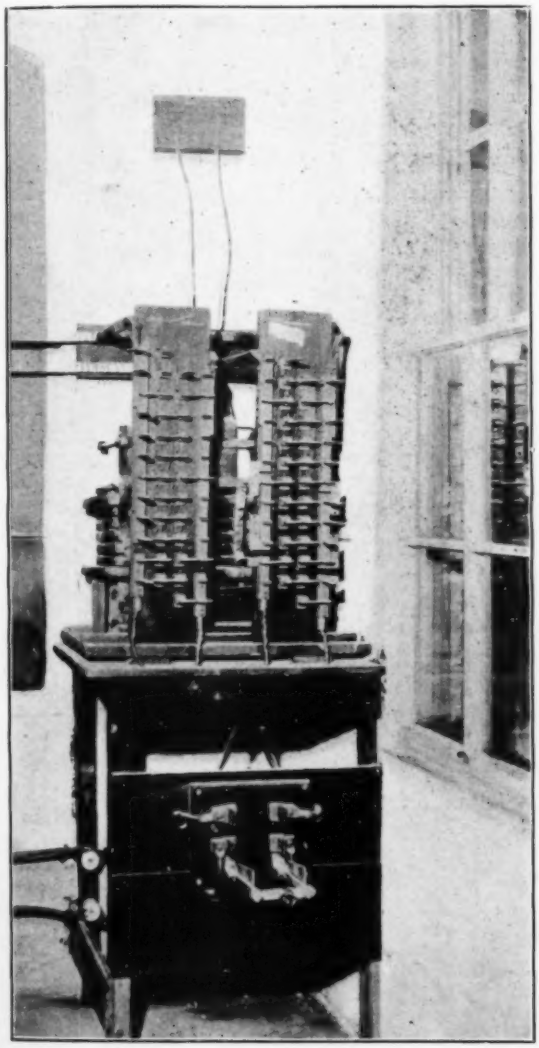


FIG. 20.—20-KW. TRANSFORMER FOR ELECTRIC FURNACES.

ton of this iron has been deposited, chemical analyses of which show no trace of carbon, manganese, silicon and other impurities commonly found in iron. An accompanying illustration shows about 200 pounds of iron in the form of cathodes, test specimens, etc.

A study of the electrolytic rectification of the alternating current, utilizing the well-known property of aluminium and other metals for this purpose, has resulted in the development of several types of electrolytic rectifiers to fulfill commercial requirements. Two types, utilizing the fused electrolyte and aqueous solutions, are shown in the illustrations.

A study of the distillation and recovery of zinc direct from its sulphide ores has yielded results of value, and the extraction of molybdenum directly from its sulphide without the usual preliminary roasting has been satisfactorily accomplished. The separtion and recovery of several of the rare elements from their ores is being studied by electrolytic and electrothermal methods.

Investigation of the conductivity of various fused materials is being made for the purpose of determining a suitable ma-

FIG. 21.—NEW CHEMICAL BUILDING.

terial for an electrically heated fused bath for tempering high-speed tool steel, the requirements of which are non-corrosive action on the steel, and electrodes, and maintenance of the electrolyte without decomposition or appreciable volatilization at about 1400° to 1500° C.

Other investigations deal with the fusion of quartz, reduction of tungsten, commercial tests of the Edison storage cell, resistance and counter electromotive force of copper refining tanks, and the determination of such physical properties of carbon and graphite as relate to the use of these materials for electrode purposes and the construction of electric furnaces.

Among experimental work which has been done within the past few years may be noted the determination of efficiency, cost and commercial considerations relative to the production of hypochlorites, tests on storage batteries of different makes, and upon storage battery plants, and a comparison of most of the dry cells on the market to determine their life, capacity, resistance, and other properties. An extended investigation upon the corrosion of iron showed, among other interesting facts, that iron under strain causes a change in the contact potential of the metal toward an electrolyte, so that a curve showing such changes is similar to the curve of the stress-strain diagram.

An electrolytic stripping process was developed for the removal of copper, brass and silver from iron. It has found extensive application in the bicycle factories of the country as an adjunct to the brazing process.

Zinc plating has been the subject of a large amount of work, and in addition to determining the conditions for the production of the best deposits, a comparison has been made of the protective properties of zinc applied by the electrolytic and by other methods.

A process has also been worked out for the deposition of durable, adherent deposits upon aluminium, as described in the ELECTROCHEMICAL INDUSTRY, March, 1904. Another line of work to which considerable attention has been given is the production of chrome yellow and other pigments.

Various other researches which have produced interesting and valuable results might be noted, but the ones mentioned serve to indicate in general the nature of the work undertaken.

Current Notes.

ELECTRIC FURNACE PROCESSES IN THE IRON AND STEEL INDUSTRIES.—The possibly great importance of industrial developments in this line is indicated by the interest with which our series of articles on various processes in this field has been received. Mr. P. McN. Bennie's article in our January issue, which is a condensed translation of Mr. G. Gin's description of his latest process, with some additional critical notes, has been reprinted literally (with the addition of a cost sheet at

the end, while we gave only a summary of the same) in the organ of the Faraday Society, the *Electrochemist and Metallurgist*, of March, and in the issues of April 23d and 30th of a New York electrical journal. While both journals do not give credit to us in their reprints, we are glad to see that Mr. Bennie's translation and annotation, as specially prepared for our columns, has found the approval of our esteemed contemporaries.—The committee appointed by the Canadian Government for the purpose of investigating the different electric furnace methods in use in various plants in Europe, has just returned, and will submit its report early in next month. While no details are given out at present, it is stated that the trip of the commission has been entirely successful, and the committee is convinced that by one of the processes which it has examined, the production of steel from ores with utilization of Canadian water powers will be a commercial success. The commission consisted of Dr. Haanel, chairman; Professor F. W. Harbord, of Copper Hill, Surrey, England, metallurgist to the Indian Government; Mr. C. E. Brown, formerly of the General Electric Company, Peterboro; Mr. Eric Nystron, mining engineer, connected with the Civil Service in Ottawa, and Mr. Thomas Cote, secretary.—The Keller furnace, described in our issue of January, 1903, and August, 1903, is stated to be applied at present on a large scale at Livet, France. They have about 4,000 hp. in operation there, making ferro-alloys, special steels, etc.

American Electrochemical Society. The following gentlemen were elected members of the American Electrochemical Society on March 4: Earl T. Ragan, Des Moines, Ia.; Margaret A. Gleaves, New York; Sarat C. Rudra, New York; Oliver P. Watts, Madison, Wis.; Edwin A. Zeller, Jr., Philadelphia; C. M. Kline, Philadelphia; Lucien Ira Blake, Lawrence, Kan.; George McQuilkin, Jr., Quincy, Mass.; Gideon Boericke, Philadelphia. The following gentlemen were elected on April 2: J. M. Barrett, Pittsburgh, Pa.; J. T. Willams, Stamford, Conn.; Franz Salzer, Philadelphia; Adelbert H. Richards, Colorado Springs, Col.; J. D. Pennock, Syracuse, N. Y.; A. J. Ewing, Minas Geraes, Brazil; F. A. Holton, Washington, D. C.; Henry Gall, Versailles, France; T. B. Stevens, Colorado Springs, Col.; George A. Hulet, Ann Arbor, Mich.; S. Sakai, Kokura, Buzen, Japan; Paterno, Rome, Italy; G. B. Chorpening, Clarksburg, W. Va.; F. P. Dewey, Washington, D. C.; A. E. Bonna, Rome, Italy. The following were elected on April 7: Robert King, Toronto, Ont., Canada; Addis Bliss Albro, New York; Ernest Stütz, New York. The names of the following gentlemen will come up for election at the May meeting of the board of directors: Herbert Haas, Redding, Shasta county, Cal.; Clarence I. B. Henning, Santa Cruz, Cal.; Franz von Kuegelgen, Holcombe Rock, Va.; F. H. Chapin, Minneapolis, Minn.; H. W. Buck, Niagara Falls, N. Y.; Henry N. Stokes, Washington, D. C.; F. A. Wolff, Jr., Washington, D. C.; Henry Walter Sykes, Syracuse, N. Y.; Charles Brandeis, Montreal, Canada; Charles H. Clarke, Berlin, N. J.; Horace H. Emrich, Perth Amboy, N. J.

Lehigh University. Among the subjects of thesis to be presented by candidates for degrees, Lehigh University, South Bethlehem, Pa., June, 1904, are the following: S. Le Roy Carron, "Plans and estimates for ozonizing plant for the sterilization of the water supply of Bethlehem, Pa.;" C. R. Peebles, "Manufacture of steel in the electric furnace;" R. L. Herrick, "Tests on the applicability of the electro-cyanide process to a Brazilian gold ore;" H. P. Barnards, "Manufacture of potassium chlorate by the electrical process.

Experiments with Radium.—A report from Vienna states that at the request of the Academy of Science, the Austrian Minister of Agriculture, "in order to facilitate the solution of certain important questions relating to the nature of radium," has ordered that from January 1 until further notice no trading should be permitted in the residues from the manufacture of uranium colors at Joachimsthal, and that 10,000 kilogrammes of those residues should be reserved for purchase by the Academy, and another 10,000 kilogrammes for M. Curie, the discoverer of radium, in Paris. These consignments are to be devoted entirely to the purpose of scientific experiment.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

Industrial Electrochemistry.

Applications of Electricity to Metallurgy.—The March issue of the *Technology Quarterly* contains a lecture by J. W. Richards on the applications of electricity to metallurgy. After an introduction on the metallurgical methods of treating ores, the author remarks that electricity is used to assist the metallurgist in three fundamentally different ways, viz., mechanical, thermal, electrolytic. The mechanical applications of electricity comprise the electromagnetic and electrostatic processes of dressing and concentrating ores. The thermal methods use the electric furnace which is either an arc or a resistance furnace. The author gives a review of the chief features of both types, and sums up the particular advantages of electric furnace heat as follows: First, heat can be generated up to 350° C., which is at least 1500° higher than can be obtained in fuel-fed furnaces. Secondly, it is applied internally, or in such close contact with the material to be heated that it is greatly more efficiently applied than the ordinary forms of heating. One horse-power-year cost from $10 to $25 at established water-power installations, and its heat-producing power is 15,000 calories per day, or the equivalent of the full calorific power of 2 kg. of good coal. This gives the heating power of a horse-power-year as that of 730 kg., or ¾ of a ton of coal. But for a given heating effect the electric heat can be applied (for instance, for melting steel) at an efficiency of 75 per cent, whereas the heat of combustion of coal is at most applied at an efficiency of 25 per cent. In general, therefore, electric heating will cost less where coal costs per ton over one-half of the price paid per electric horse-power-year. This is on the assumption that coal can be so used as to produce the effect desired, and ignoring many other advantages which electrical heating possesses, and which in many cases make its use preferable even at several times the cost of a ton of fuel per horse-power-year. Electrolytic methods, as applied to metallurgical purposes, are classed under three heads. First, the material being treated is the electrolyte or part of the electrolyte; second, the material is the anode or placed in contact with the anode; third, the material is the cathode or placed in contact with the cathode. The author discusses the phenomena of electrolysis and its attendant chemical phenomena, the reducing action at the cathode and the perducing (oxidizing) action on the anode. In electrolyzing a fused metallic salt, it is almost an invariable rule that the output of metal will represent more nearly 100 per cent ampere-hour efficiency the nearer to its melting point the salt is when electrolyzed. If a fusible compound of the metal desired is not readily obtainable or a suitable one not to be found, the problem may be solved by the method of dissolving it in a solvent, as Hall does in his aluminium process. Hall sought for a fusible salt which would dissolve alumina, and be electrically more stable than alu-

mina. He found the solvent in a mixture of fused sodium fluoride and aluminium. The author expresses his surprise that the same priciple has not been applied to the reduction of other metallic oxides. Easily fusible silicates of manganese and calcium, for instance, would dissolve manganese oxide to a considerable extent which would be decomposed by the passage of the current. He considers this principle one of the most promising fields for experiment in the whole realm of electrometallurgy. Salom's principle of reducing lead from galena by cathodic reduction seems also to have a wide range of application.

Manufacture of Iron and Steel in the Electric Furnace.—In *Dingler's Polytechn. Jour.*, April 2 and 9, A. NEUBURGER gives a review of the processes of Stassano, Heroult and Keller for producing iron and steel from ores in the electric furnace. His account of these processes does not seem to contain any new details. The author arrives at the following conclusion. He refers to the opinion of Goldschmidt that the electric manufacture of special steels is capable of competing with crucible steels in Germany. Gin is of the same opinion. He thinks that the electrometallurgical treatment of iron ores is impracticable in countries with cheap coal and cheap freight rates, but that the prospects are very favorable for the electric manufacture of the better grades of steel from cast-iron, made in the blast furnace. Both Gin and Goldschmidt think that the Martin furnace may be advantageously replaced by apparatus in which electrical energy is used. The best results will be obtained—even in districts where coal is plentiful—if the waste gases of the blast furnace are utilized for producing the electrical energy; electric power will then be so cheap as to be able to compete with water power, and Gin considers such a plant as of ideal technical perfection. It would represent a combination of an ordinary blast furnace, a Bessemer converter for making the cheaper grades of steel, and an electric furnace for making the fine steels. The author finally remarks that in Germany the electric manufacture of tool steels has recently been undertaken on a commercial scale.

Ferro Silicon.—While in the commercial manufacture of ferro-silicon, carbon is always used as a reducing agent, an important advantage would be obtained if it was possible to bring about a reaction between sulphide ores and quartz as to yield ferro-silicon and sulphur dioxide according to the equation $FeS + SiO_2 = FeSi + SO_2$. From a patent, taken out by Aschermann, it would appear that such a reaction can be produced. In a paper published in *Metallurgie*, April 8, and *Stahl und Eisen*, April 1, AMBERG gives, however, an account of a series of laboratory experiments in which he tested the above reaction. He used iron sulphide and silicon dioxide in various greatly varying proportions, and also used an addition of lime, without obtaining satisfactory results, the reaction being very slow and the yield of ferro-silicon small, so that he does not think that the reaction which really takes place is represented by the above equation. He has little hope for a commercial success in this direction.

Calcium Carbide.—Calcium oxide is reduced by carbon only at a temperature at which the former becomes liquid. The manufacture of calcium carbide, therefore, requires an enormously high temperature, and an electric furnace to produce it. H. MOISSAN points out, however, the possibility, although not practicability, of another method in a paper published in *Comptes Rendus*, March 14, and abstracted in the London *Electrician*, April 8. It is based on the fact that metallic calcium combines with lamp black to produce calcium carbide at any temperature above red heat. In any electrolytic process, therefore, where calcium is produced in contact with carbon at a red heat, calcium carbide is formed. His new carbide process is based on these considerations, but it apparently has no commercial value, since the carbide obtained is firmly embedded in a fused mass of calcium chloride and fluoride. A graphite crucible, which serves as the positive pole, is filled with calcium chloride fused by means of a small electric arc. A vertical rod of graphite serves as a negative electrode. The chloride is put in gradually, and after the first fusion electrolysis is carried out by means of a current of 10 to 15 amperes at 120 volts. Chlorine is given off freely, and after an hour the process is stopped and the crucible broken. Under the crust is found a mass with a crystalline fracture. The central portion dissolves in water, and evolves a mixture of gases containing some 14 per cent of acetylene, the rest being hydrogen. The process is greatly improved by mixing the chloride with a quarter of its weight of fluoride, which makes the fused mass more fluid and the conduction of the current more regular. The amount of carbide obtained is small, but it may be increased by adding to the liquid a coarsely-powdered mass of petroleum coke.

Ozonizer.—The Elworthy ozonizer is described in the April number of *Elektrochem. Zeit.* by the inventor. From the apparatus of Siemens & Halske it is distinguished by the feature that the low temperature which is required for getting a sufficient yield of ozone is not produced by water cooling, but by using a high-speed for the passage of the air through the ozonizer, and by passing the air twice through a field of silent discharges. Metal solenoids, which form the poles of the silent discharges, are placed in a small glass tube, and in a large glass tube, which surrounds the former. The air passes first through one tube, and then through the other. Ten of such tubes are combined in one apparatus, which is operated by an alternator giving three to four amperes and 125 to 135 volts, the tension being raised in a special transformer to 11,000 to 12,000 volts. The air is passed through the tubes by means of an air pump. The yield of ozone is 60 to 70 grams per kilowatt-hour, the concentration of ozone in the mixture of air and ozone 0.4 to 0.5 gram of ozone per cubic meter. The ozonized air leaving the apparatus has a temperature of 20° higher than the surrounding atmosphere. To obtain a higher concentration of ozone, the air is passed through several apparatus in series, cooling devices being inserted between each two apparatus. While ozone has found practical application so far mainly for the sterilization of water, it is stated that it may be used also in bleaching, for ageing wine, in the manufacture of soap, perfumes, etc., and especially in the petroleum industry, since it is claimed that all kinds of petroleum when treated with ozone for two to ten hours, lose the strong petroleum odor and give a clear, quiet white light like incandescent lamps. Ozone may also be used as an oxidizing agent in special cases of chemical industries.

Fixation of Nitrogen from Air.—An experimental study of the yield of nitrogen oxides from air by the flame discharge, and on the influence of the length of flame and of the temperature was made by F. VON LEPEL, an account being given in *Berichte*, 1904, vol. 37, page 712, and abstracted in the *Jour. Soc. Chem. Ind.*, April 15. When the discharge occurs between a copper wire anode and a carbon cathode, the poles are clearly differentiated, both by the naked eye and by the spectroscopic appearance of the flames; and this difference is also shown in the chemical effects of the discharge, for the gases drawn from the immediate vicinity of the cathode contain a much larger proportion of nitric oxide than those taken close to the anode. Receding from anode and cathode, however, the proportions respectively increase and decrease, so that at 5 mm. from the anode, the air surrounding the flame is richer in nitric oxide than at 20 mm. from the cathode. Naturally the highest total yield of nitrogen oxide is got by taking the air surrounding the flame along its whole length. The author considers that the formation of nitrogen oxides is due to direct electrical action, and is not solely thermal, as Muthmann and Hofer suppose. In experiments in which the voltage and current in the primary were kept constant, the temperature of the air at a certain distance from the flame (and hence, presumably that in the flame itself) rose as the speed of rotation of the anode was increased from zero, and also

as the length of the flame was increasd. The yield increased with the temperature (to a quickly reached maximum) only when the anode was fixed. The best yield was always obtained with a medium temperature. The frequency of the interrupter was also varied, but moderate frequency was found to give the best results; a Wehnelt interrupter is not suitable. The yield is increased by soaking the cathode in various salt solutions, such as potassium hydroxide, copper sulphate, or titanium chloride. The solution of nitrate and nitrite obtained by neutralizing with sodium carbonate the aqueous solution of the nitrous gases produced by the process can be used as manure, and is apparently as efficient as Chili saltpetre, so that for this purpose the conversion of the nitrite into nitrate is not necessary.

Electrolytic Preparation of Iodoform from Acetone.—J. E. Teeple publishes an interesting paper on this subject in the February issue of the *Journal of the American Chemical Society*. He refers to Schering's electrolytic method of preparation of iodoform from alcohol and shows that the preparation from acetone would have certain advantages. In his method the electrolyzing cell was a rather deep crystallizing dish; the anode, a piece of platinum foil of 0.4 sq. dm. surface lying on the bottom of the dish; the cathode, a piece of platinum wire just dipping beneath the surface of the liquid. A stirrer driven by a small motor kept the solution in active motion. The cell stood in a bath and the temperature was usually kept at about 25° C. or lower. The solution consists of 25 or 30 grams of potassium iodide, 200 to 250 cc. of water, and 2 cc. acetone. He used an anode current density of one to six ampere per sq. dm., and an e. m. f. of 3 to 12 volts, according to the concentration, the temperature, the current density and the distance between the electrodes. When the perfectly neutral solution of potassium iodide was then electrolyzed in the presence of acetone without a diaphragm, the current yield was only about 50 per cent, but it may be made almost theoretical if the excess of alkali is neutralized as soon as it is formed. As reagents for neutralizing he used successfully carbon dioxide or hydrochloric acid or hydriodic acid or iodine; the last seems to be the most practical one.

Silver Plating.—A note in *Metal Industry*, April, deals with cyanide versus chloride in the silver bath, the bath consisting of a solution of either the cyanide or chloride of silver in cyanide of potash. Chloride is sometimes preferred because it is much more rapidly made than the silver cyanide. On the other hand, platers who produce the highest grade of work, and that which wears the best, invariably use the cyanide of silver. It is said that work plated in a chloride bath does not stand the burnishing nearly as well as that produced in the cyanide bath, but is much more apt to strip under the tool. The solvent action of the anode is also much less, and it is much more difficult to keep the bath in a uniform working condition.

Brass Plating.—The April issue of *Metal Industry* contains an article by F. P. Davis on brass plating solutions, their use and abuse. He classifies brass solutions into those suitable for heavy deposits and those for light, bright deposits, to be lacquered with no further finish. Both baths are made from freshly prepared carbonates of copper and zinc; two parts of weight of the former and one part of the latter. The cell is first half filled with pure water with some pure cyanide of potash, then the copper carbonate is added and afterwards the carbonate of zinc, dissolved in cyanide, is added. The bath is used at a temperature from 100 to 110° F. and the solution should stand at 5 to 5½ Beaume. The anode is made of first quality clean yellow brass, and its surface should be equal or in excess of that of the cathode. The rules for preparing the solution, with the precautions to be taken, are given at some length.

Cadmium.—In the March issue of the *Electrochemist and Metallurgist*, S. Cowper-Coles gives a review of what has been done in the electrodeposition of cadmium and its alloys.

Theoretical and Experimental.

Determination of Latent Heat of Fusion and of Specific Heat of Metals at High Temperature.—While this is a matter of considerable importance for applying the methods of thermochemistry to electric furnace reactions only few data are so far available. In *Metallurgie*, March 22 and April 8, F. Glaser describes a method which he has found useful for determining the specific heats of solid and fluid substances at temperatures up to 1100° C., having applied it to measure the specific heat of lead, zinc, aluminium, copper and tin, and to calculate the latent heat of fusion. The principle of the method is well known, the substance to be investigated being heated to a certain temperature, then quickly brought into water and the temperature increase of the latter being measured. His apparatus is shown in Fig. 1. The calorimeter is a sheet-iron box, 350 by 350 by 400 mm., placed in a wooden box upon pieces of rubber, the space between the iron box and the wooden box being filled with wood, and two stirrers are placed in opposite corners. The total quantity of water was determined before each experiment as follows: The calorimeter was filled partly with water, the stirrers were started and the course of temperature was taken; simultaneously another quantity of water was brought to a higher temperature, the course of its temperature was measured, and shortly before pouring it into the calorimeter the weight was determined. The increasing temperature in the calorimeter was then measured. Above the calorimeter, the electric furnace is placed. Upon a firebrick ring of 65 to 70 mm. internal diameter is placed a carbon ring which serves as one pole for the current and surrounds the lower end of a tube of refractory material. Upon the carbon ring an external cylinder of firebrick is placed so that there is a space left between it and the internal refractory tube. This space is filled with small pieces of retort carbon. The upper end of the apparatus is closed by two carbon blocks, through which the thermo-element is introduced. The metal to be tested is placed in the inner tube, and the method by which it is dropped into the calorimeter is clearly shown in the figure. The author gives the results of his measurements, the specific heats being determined first for ordinary commercial metal, and then for chemically pure metals. The specific heats of the pure metails are generally somewhat smaller. The latent heat of fusion for one gram was found as follows: Lead 4.78 calories, zinc 29.86 calories, aluminium 76.8 calories, copper 41.63 calories, tin 13.62 calories. The only difficulty at high temperatures was experienced with molten copper at 1190° C. When a quantity of 3 to 4 kg. was dropped into the water there was something like an explosion. By applying a larger water calorimeter and more energetic stirring the author hopes to be able to extend the higher limit of temperature further upwards. For the latent heat of fusion of metals, J. W. Richards (*Chem. News*, vol. 75, page 278) has developed an empirical rule according to which one-third of the total heat absorbed by the substance from the absolute zero point of temperature to the point of fusion, equals the latent heat of fusion. He found that in general the calculated and measured values agree together, with the exception of aluminium, for

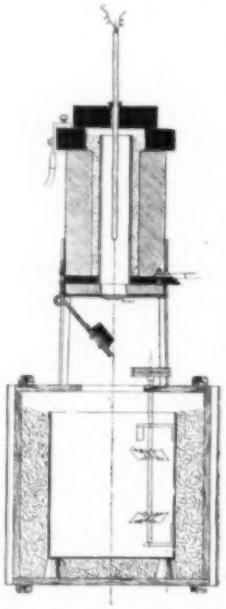


FIG. 1. APPARATUS FOR DETERMINING SPECIFIC HEATS.

which 70.4 was calculated and 100 was measured. The value found by the present author—76.8—agrees better with the calculated value, while in the case of zinc the difference between the calculated and measured values becomes somewhat greater.

Electrical Conductivity of Aqueous Solutions at High Temperatures.—The February issue of the *Journal of the American Chemical Society* contains a lengthy and important paper by A. A. NOYES and W. D. COOLIDGE. After working three years, they succeeded in constructing a platinum line bomb with electrodes insulated by means of quartz crystal cylinders. The bomb remains perfectly tight at any rate up to 306°, and occasions only an unimportant contamination even in salt solutions as dilute as 1-2000 molar. It yields conductivity measurements accurate to 0.25 per cent or less, and at the same time makes possible specific volume determinations which are essential to the interpretation of the results. The authors have thus far been able to investigate only two dissolved substances—potassium and sodium chloride—but have made conductivity and specific volume measurements with these solutions at various temperatures ranging from 26° to 306° C., and at various concentrations between 0.1 and 0.0005 molar. Even at the highest temperature the dissociation calculated from the molecular conductivity ratio does not change with the concentration in much closer accord with the requirements of the mass-action law than at the ordinary temperature. The empirical formula of Kohlrausch $\Lambda_0 - \Lambda = KC^{1/2}$ was found to represent the results most satisfactorily. The conductivity values extrapolated for infinite dilution, and therefore the migration velocities of the ions, were found to be an approximately linear function of the temperature throughout the whole range of temperatures in the case of sodium chloride, and up to 218° C. in the case of potassium chloride, the deviations being moreover not very large (3.5 per cent) even at the highest temperatures with the latter salt. The ratio of the conductivity of KCl and NaCl at infinite dilution decreases from 1.19 at 18° to 1.04 at 306°, showing that the migration velocities of the sodium and potassium ions are slowly approaching equality. The degrees of the dissociation of the two salts are nearly identical at all temperatures and concentrations. The dissociation in a 0.1 normal solution has approximately the following values, 84 per cent at 18°, 79 per cent at 140°, 74 per cent at 218°, 67 per cent at 281° and 60 per cent at 306°.

Electric Conductivity in the Neighborhood of the Critical Point.—The electrical conductivity of solutions has recently been applied to the study of the critical phenomenon. It has been shown, not only that solutions conduct beyond the critical point, but that the vapors of these solutions become conducting before the critical point is reached. In a paper published in the January and February issues of *Physical Review*, C. A. KRAUS gives an account of measurements of the change of the electric conductivity of solutions in methyl alcohol in the immediate neighborhood of the critical point. Solutions in methyl and ethyl alcohol possess maxima of conductivity, the former in the neighborhood of 150°, the latter in the neighborhood of 100°. Such solutions conduct beyond the critical point, those in methyl alcohol conducting much the better. The temperature coefficint of solution in methyl alcohol undergoes a certain change at the critical point. An unsaturated vapor solution exhibits no discontinuity at the critical point of the solvent. Solutions which consist of mixtures of gasogenous and liquidogenous molecules exhibit a great change of the conductivity immediately beyond the critical point, but a discontinuity of the tangent cannot be established. Methyl alcohol presents the same phenomena of non-homogeneity beyond the critical point as do other liquids studied in this connection. The author also studied the conductivity of solutions possessing the same concentration of solute and different densities of solvent For large quantities of solvent present, the conductivity is nearly proportional to the quantity of solvent. For smaller quantities of solvent present the ratio of increase of conductivity is much smaller. As the critical point is approached, the ratio of increase of conductivity with increase of solvent is increased. The vapor of a solvent may become a very good conductor in the neighborhood of the critical point. The conductivity increases very largely for a saturated vapor as the critical point is approached, owing to increasing density of both solvent and solute.

Action of Salts upon Amalgams.—In our February issue, page 67, we gave an abstract of an article by Fernekes on the action of sodium and potassium amalgams on various aqueous solutions. The author concluded that his observations could not be explained by the electrolytic dissociation theory, and that they were readily explained by a theory of Kahlenberg. The March number of the *Journal of Physical Chemistry* contains a paper by G. McP. SMITH, who thinks that the action referred to in the former paper "could be much more plausibly explained by the ionic theory of Arrhenius than by the hypothesis of Kahlenberg, as follows." A solution of potassium chloride, containing positively charged potassium ions, in contact with sodium amalgam brings about the replacement of the sodium in the amalgam by potassium in the following manner. The positive electron of the potassium ion is neutralized by the negative electron of a neutral sodium atom (containing both a positive and a negative electron) upon coming in contact with the latter and thus leaves the sodium atom positively charged, *i. e.*, an ion; the potassium atom entering into the amalgam and the sodium ion into the solution. How much sodium is thus replaced depends upon the condition under which the experiment is carried out. If a relatively large number of potassium ions are in the solution, as compared with the number of sodium atoms in the amalgam, the sodium of the amalgam is according to the law of mass action almost entirely replaced by potassium, and after this has happened, the potassium (and the remainder of the sodium) in the amalgam is free to act on the solution, which now contains both potassium and sodium ions. This accounts in a very satisfactory manner, for example, for the slow action of sodium amalgam on a solution of potassium chloride. At the beginning, the main process consists in the replacement of sodium by potassium, and, as soon as an equilibrium has been approached in this direction, the resulting amalgam is free to act on the water of the solution with the evolution of hydrogen, and the formation of potassium (and sodium) hydroxide. It is now easy to see why this action is retarded. The sodium and potassium ions of the solution tend to prevent the entrance of more sodium and potassium in the ionic state. He gives rules for the preparation of the amalgam containing sodium from potassium amalgam.

Decomposition Curves of Lithium Chloride in Alcohols and the Electrodeposition of Lithium.—The March issue of the *Journal of Physical Chemistry* contains the complete paper by H. E. PATTON and W. R. MOTT on this subject, an abstract of which was published in ELECTROCHEMICAL INDUSTRY, August, 1903. The authors remark that they reserve all patent rights and state their claims broadly as follows: They have discovered and used new classes of solvents for the electrolytic separation of alkali metals (such as lithium, sodium, etc.) and alkaline earth metals (such as magnesium, calcium, strontium, etc), and other metals not easily obtained from aqueous solutions. They define and claim as their invention, the use of organic solvents fulfilling the two conditions: First, there should be present in the solvent not less than three carbon atoms. Second, one or more of these carbon atoms should (*a*) be the center of a carbonyl group (which includes aldehydes and ketones, such as acetone, etc.) or (*b*) have bound to it an hydroxyl group (this includes propyl alcohol, butyl alcohol, amyl alcohol, phenol, etc.).

Non-Aqueous Solutions.—The February issue of the *Journal de Chimie Physique* contains a very useful summary by P. DUTOIT on the numerous researches on conductivity, dissociation and properties of electrolytes in solvents other than

water. The subject is discussed under the following headings: Ionizing power, electric conductivities, transport numbers, molecular weights, differences of potential and electrolysis, properties of dilute solutions, chemical reactions. Since the paper itself is a concise statement of our present knowledge of the subject it cannot be briefly extracted. As an appendix a long list of papers on the subject is given.

Dielectric Capacity of Atoms.—The electron theory imparts more interest than ever to the investigation of the properties of atoms. At the present stage of this theory the electrical properties of atoms demand investigation from every possible point of attack. In a paper published in the April issue of the *Philosophical Magazine*, W. Sutherland discusses the dielectric capacity of the atom. He had formerly developed a theory which enabled him to calculate the ionic mobility from certain constants, among which was the dielectric capacity of the stuff of the atom. If the latter would be calculated from the refractive index according to Maxwell's well-known formula, his formula for ionic mobility would lead to approximately correct results in some cases, but to absolutely wrong results in others. He concludes that if the ions, besides their free charges contain neutral electric doublets (for instance a monovalent chlorine ion being assumed to have combined with it one negative electron and three doublets, each doublet consisting of a positive and a negative electron) then the presence of these doublets may produce an abnormal effect on the propagation of light, and we shall not be justified in using Maxwell's relation for finding the dielectric capacity from the refractive index. The author now proceeds in the reverse way. He bases his calculations on his formula for the ionic mobility and calculates from Kohlrausch's mobilities the dielectric capacity of the ion. The results are given in a table which shows that on this basis the dielectric capacity of an atom becomes directly proportional to the valency and inversely proportional to the square root of the volume of the atom. It is interesting to find that valency which Faraday proved to be of fundamental importance in his electrolytic law, is of similar importance in connection with dielectric capacity. As to the physical significance of the above law, he gives the following train of speculation. As he has formerly shown, cohesion can be traced to the mutual attractions of the electric doublets in molecules, acting like minute magnets; thus cohesion is an electrical phenomenon. By following a similar train of reasoning, it can be shown that rigidity in solids is a mechanical result of the electric doublets in the molecules. At absolute zero the rigidity is equal to the electric energy of these doublets per unit volume. But to express this electric energy we must regard it as proportional to the square of an electric quantity associated with a molecule. Thus, rigidity is proportional to the square of an electric quantity. Now the above law for the dielectric capacity of the atom means that the square of dielectric capacity divided by valency for an atom when multiplied by the volume of the atom is the same for all. It seems, then, as though a certain stock of electric energy associated with the electrons in an atom were the same for all atoms. The above law seems to be of a similar nature to that of Dulong and Petit, and of the fundamental law of molecular physics which makes the kinetic energy of translation of all molecules at a given temperature the same. A conclusion to be drawn directly from the law is that the ionic velocity is directly proportional to the square root of the radius. This brings out neatly the old paradox about ionic velocities. Hitherto it has been assumed that the ionic velocities have been measured with the same driving force for all ions. The result that a large ion like that of K travels faster than a small one, like that of Li under the same driving force in a resisting medium is, indeed, puzzling until, in taking account of the dielectric capacity of the atom, we see that the driving forces assumed equal, are in reality not so at all.

Indicators.—An account of two investigations on the sensitiveness of indicators, by W. Salessky and B. Fels is given in the *Zeit f. Elektrochemie*, March 25. For investigating the sensitiveness of indicators Nernst has proposed to determine the potential difference of a hydrogen electrode against a solution provided with the indicator to be tested, while it is about to change color. Salessky shows that it is possible to determine the concentration of the H ions at the moment when the color changes, by making use of concentration cells. Fels has determined the concentration of the H ions by another method and found that both methods give approximately the same results.

Laboratory.—A description with drawings of the new laboratory for physical chemistry and electrochemistry at the Institute of Technology of Karlsruhe, is given by Le Blanc in *Zeit. f. Elektrochemie*, April 8.

Electrolysis of Water.—A simple and inexpensive apparatus for the electrolysis of water for lecture experiments in small colleges is described by J. L. Beeson in the March issue of the *Journal of the American Chemical Society*. It is essentially a glass tube exactly of the general form of a tuning fork with graduated arms and platinum wires fused in each arm.

Batteries.

Theoretical Capacity of Lead Accumulators.—In *L'Industrie Electrique*, March 25, Loppe publishes a theoretical article in which he calculates the very highest ampere-hour and watt-hour capacities which a lead accumulator can have per kilogram of total weight, if of the highest perfection, which can be obtained in practice. The calculations are based upon the amounts of material required for the chemical action according to Faraday's law, the reaction being assumed to be that required by the double sulphate theory, and the following assumptions are further made: The "practical capacity" of an accumulator is two-thirds of the "total capacity" (the latter being the capacity, if the discharge is driven down until the e. m. f. becomes zero). For the ratio of the weight of active material to the total weight of the plates the high value 0.8 is assumed. For the calculation of the weight of the electrolyte he assumes that at the end of the charge the elctrolyte has a density of 1.285, and at the end of a discharge 1.125. For the ratio of the weight of the total cell to the weight of plates and electrolyte together the low value of 1.15 is assumed. All these assumptions represent conditions under which the utilization of the active materials in the accumulator would be extremely high, so that the results at which he arrives represent maximum figures which one has to strive at in practice rather without hoping to attain them. He finds that under these conditions a total weight of 35.57 grams per ampere-hour capacity is required. This weight is the sum of that of the electrodes, 15.38 grams; electrolyte, 15.55 grams, accessories, 4.64 grams. For the maximum capacity per unit mass of a lead accumulator he, therefore, finds 28.1 ampere-hours per kg. and 53.39 watt-hours per kg.

Weston Cell.—Considerable work has recently been done on the Weston Cell. Two papers by Carhart and Hulett and Wolff on this subject are extracted in the report of the Electrochemical Society Meeting on another page of this issue. The March issue of the *Journal of Physical Chemistry* contains a paper by H. T. Barnes and S. P. Lucas, who think that it is a matter of small moment which cell, the Clark or the Weston, is adopted as an official standard, since the ratio of the one to the other is known so closely. Both cells have points to recommend them for different types of work, but it is evident that the Clark cell, with its high-temperature coefficient, will retire more completely into the laboratory as time goes on, leaving to the Weston cell the more active part as a general working standard. All forms of the Clark cell, containing a saturated solution, have the same temperature coefficient, the only type possessing a different one being the Carhart-Clark with dilute solution. In the case of the Weston cell it seems from the investigations of the authors that four

coefficients are possible, depending on the state of the cadmium sulphate solution. Cells with solution saturated at 0° C., have practically no temperature coefficient. Cells with a saturated solution of constant strength have a temperature change of 0.0038 per cent per degree. Cells with moist crystals and a 13 per cent amalgam have a temperature change of 0.0055 per cent and cells with moist crystals with a 14.7 per cent amalgam have a temperature change of 0.008 per cent per degree. The authors confirmed the mean value obtained at the Reichsanstalt for the ratio of the Clark at 15° to the Weston at 20°, which is 1.40665. In the February issue of the *Physical Review*, S. J. BARNETT gives in form of curves the results of a series of experiments on the polarization and recovery of cadmium cells.

Primary Cell.—A Faraday Society paper by E. G. P. BOUSFIELD, published in the London *Electrician*, April 15, refers to a cell consisting of an inner porous cup with nitric acid and a carbon pole, and of an outer vessel containing sodium hydrate solution and a metal pole, preferably of zinc. The best results are obtained by using nitric acid of maximum conductivity—namely, a 31 per cent solution—and sodium hydrate of maximum conductivity, or of a strength slightly below this, *i. e.*, a solution of from 12 to 15 per cent. On open circuit an e. m. f. of 2.6 volts may be obtained. It is claimed that the cell "may be short-circuited far longer than most cells before it runs down." The e. m. f.'s are given, if various other metals are substituted for zinc and other acids for nitric acid. Experiments were also made with two carbon poles, instead of using one carbon and one metal pole. "As was to be expected, a considerable e. m. f. was still present. This e. m. f., however, I did not succeed in obtaining very constant; it varied considerably with the carbons used, the extreme e. m. f.s registered being 1.1 and 1.8 volts. The mean e. m. f. worked out from a large number of experiments was 1.35 volts. This is no doubt an example of an e. m. f. which is commonly put down to the difference in velocity of the ions of the respective liquids." (This conclusion is open to strong objections, since the author entirely neglects the reduction and oxidation processes which he necessarily gets in the electrolyte at the inert cathode and anode, respectively. The action in the Becquerel cell, which consists of platinum plates in acid and caustic potash, respectively, and which is cited by the author for sake of comparison, has been completely explained long ago by Ostwald. The following conclusion of the author must therefore also be disputed.) From his results he thinks that the e. m. f. of the cell is made up thus: "e. m. f. due to two liquids in contact 1.35 volts, e. m. f. due to the introduction of soluble zinc pole 0.95 volt, total e. m. f. 2.6 volts."

In an article of *Elektrochem. Zeit.*, April, K. HEINTZ describes another primary cell, without, however, giving the most essential details. The main point he makes is that it is not necessary to remove the consumed depolarizer completely, but only about one-eighth of it, and then substitute for this small part a regenerating solution which brings the depolarizer back to its initial state. The depolarizer is called "nitron;" the electrodes are zinc and carbon.

MISCELLANEOUS.

Benzine Fires.—In chemical cleaning and dyeing works sudden fires have sometimes occurred, starting when the workingman draws the cleaned woollen material out of the bath. Richter has formerly found that in moving the woollen material through the benzine, the latter becomes negatively charged and the wool positively charged, this being simply an example of electricity produced by friction. When the material is taken out of the bath, a spark discharge may take place and the explosive mixture of benzine vapor and air is ignited. This occurs especially at lower temperatures. Richter has found that the addition of a small amount (one-twentieth to one-fiftieth per cent) of oleate of magnesium to benzine prevents such fires. In an investigation, the results of which are published in the *Zeit f. Elektrochemie*, March 25, G. JUST has endeavored to find the explanation of the effect of this addition. He finds that it is due to a considerable increase of the conductivity of pure benzine by the addition. If a vessel, as used for the determinations of conductivities by Kohlrausch's method, is filled with benzine, and one electrode is connected to earth and the other to an electroscope, then, if a charge is impressed upon the latter, it retains it for several minutes. If, however, one-twentieth per cent of oleate of magnesium is added it is nearly impossible to charge the electroscope, the electroscopic charge flowing off immediately through the solution to the earth. He has devised a small apparatus which enables one to find out in chemical dyeing works whether the solution has a proper conductivity to prevent fire. In Fig. 2 A is a small electroscope, which is connected with the electrode B. The second electrode C is earthed. If the space D is filled with a solution to be used in the dyeing works, the electroscope must not retain an electric charge, if the solution is in proper condition.

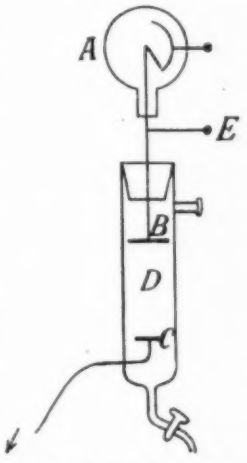


FIG. 2.—TESTING DYEING SOLUTION

Calcites.—The *Lead and Zinc News* of April 4 contains an illustrated article on the crystallography of the calcite of Joplin, by O. C. FARRINGTON.

Organic Products.—A review of the chemical industries of organic products in the United States is given by W. VIEWEG in *Chem. Zeit.*, April 1, on the basis of the reports of the Fifth International Congress for Applied Chemistry, in Berlin.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Rotatory Electric Tube Furnace.—H. N. Potter, New Rochelle, N. Y. Patent 756,891, April 12, 1904. Application filed November 21, 1901.

This resistance furnace consists essentially of a tube of carbon, lined on the inside and coated on the outside with a layer of fused magnesia. This layer is actually fused to the surface of the carbon tube, by placing the latter in a horizontal position, heating it to a temperature high enough to melt the magnesia and then rotating the tube so as to distribute the molten material evenly over its surface. The apparatus thus prepared is connected as resistance between the poles of an electric circuit. Fig. 1 shows construction whereby the furnace can be rotated and set at any desired angle, to adapt it to

the different characteristics of materials which are introduced at the upper end and have to pass through the tube by their own weight. A furnace of the above construction, having a two-inch bore and a length of one foot, is stated to take over 1000 amperes at five volts. It is proposed to transform this current into one of say five amperes and 1000 volts. For this purpose transformers are mounted together with the tube furnace, in a barrel or on trunnions within a suitable cage, so that the whole combination can be rotated. In operation, current enters the transformers from the line and the secondaries supply the tube with the requisite current. The tube, with its covering of magnesia, is surrounded by a jacket of lime, which, in its turn, is covered by an outer casing tube of tile or Portland cement. The terminal connections are made through split rings of metal, rings of carbon being interposed between the metallic rings and the ends of the tube.

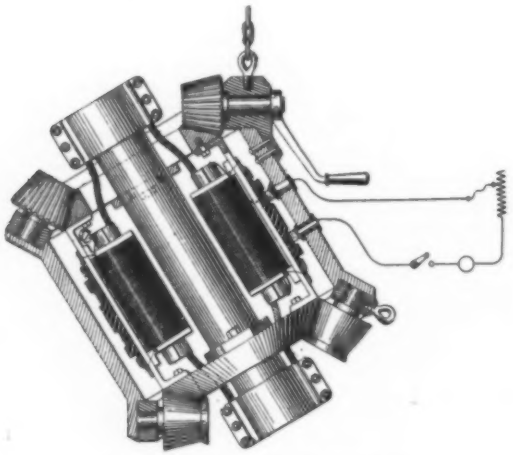


FIG. 1. ROTARY TUBE FURNACE.

Manufacture of Cyanamide Salts.—G. Erlwein, Berlin, Germany. Patent 757,185, April 12, 1904. Application filed August 16, 1902.

The invention relates to the production of cyanamide salts by means of carbon, lime and nitrogen. A mixture of lime and carbon in such proportions as are required for the formation of cyanamide, e. g. 56 CaO and $24C_2$, is subjected to the action of a high temperature, preferably in an electric furnace. The furnace shown diagrammatically in the specification is of the conventional rectangular, box-like form, with carbon electrodes introduced opposite to each other through the end walls. An outlet pipe for the gases generated during the operation is arranged in the upper part, while an inlet pipe for the nitrogen is shown above the bottom. The mixture of coal and lime is heated in this furnace to about 2000° C., whereas the temperature necessary for previously-formed calcium carbide to combine with nitrogen lies somewhere between 800° and 1000° C. When the above temperature is reached, the nitrogen is sent through the mixture, the rate of speed at which it is introduced being so regulated that it is absorbed as completely as possible. The operation is regarded as complete, when it is found by analysis either of the material or the escaping gases that the nitrogen is no longer absorbed. Instead of charcoal and lime, a mixture of charcoal with calcium carbonate may be employed, or a metal, like iron, might be added to the mixture for the purpose of increasing the conductivity. Not only mixtures containing lime and carbon in the theoretical proportions (56CaO and 24C) may be used, but also a further addition of charcoal or organic materials containing carbon, as sawdust, pitch, tar or the like, may be made to supplement the cyanamide-forming mixture. This diminishes the necessity of great care in operation.

Apparatus and Processes for the Electrolytic Production of Metals and Compounds; Precipitating Metals from Solutions. C. Butters, Berkeley, Cal. Patent 756,211, April 5, 1904. Application filed October 3, 1902.

The invention has particular reference to the electrolytic precipitation of gold and silver from cyanide solutions. The cathodes are sheets of metal, coated with tin, the so-called tin plates of commerce, while the anodes are lead peroxide. They are usually placed three inches apart, and the solution is made to flow between them, preferably in an upward or downward direction, at a uniform velocity. A high current density is used for the purpose of depositing the gold in a loose, slimy form on the tin cathode, so as to be able to brush or wipe the deposit off easily. This operation is usually performed once a day, by running a wiper over the plates while they are in position in the electrolytic tank. The removed slime is allowed to settle on the bottom of the apparatus, and the separation and refining of the metals is carried out in the usual way. In practice a current density of about 0.5 ampere per square foot of cathode is found suitable in most cases. To obtain the most suitable current density at the cathode, the voltage is made to vary with the conductivity of the solution and adjusted until the metal deposits just loosely enough to be wiped off easily. Mr. Butters has been one of the most active pioneers in the field of electrolytic precipitation of gold, first in South Africa, and in more recent years in this country and Mexico. (Concerning the industrial application of this process see the paper by E. M. Hamilton in ELECTROCHEMICAL INDUSTRY, April, 1904, page 131.)

Process of Treating Low-Grade Ores and Tailing by Electrolysis.—Ernst Fahrig, Philadelphia. Patent 756,223, April 5, 1904. Application filed May 9, 1903.

The ores and tailings to be treated are first crushed to any desired mesh above 20, and are then introduced into a vat, water and a suitable electrolyte being added, until the quantity of both that has been admitted, amounts to about 60 per cent of the dry ores and tailings, and forms a sufficiently liquid pulp. The latter is then lifted to the top of a square or rectangular tower, the walls of which are provided with a series of inclined sheet copper plates, which serve as cathodes and are sufficiently thick and strong to stand the pressure of the pulp which is passed over them and flows downward from one to the other. Below each cathode is arranged an anode of graphite. The voltage is approximately five to seven volts and the current 0.08 to 0.1 ampere per square foot of cathode. For the electrolytic precipitation of the precious metals two to five volts and a current density of from 0.05 to 0.06 per square foot of cathode surface are preferred. The electrolyte may be any oxychloride or chlorides, or a weak solution of potassium cyande or "hypochlorid." The pulp flows down the tower, and the precious metals are deposited on the cathode plates, while the partially extracted pulp passes into a mercury trap standing on the bottom of the vat in which the pulp was prepared, and overflows into the latter vat, whence it is again pumped up to the top of the tower to be retreated as before. This treatment is repeated for about an hour per ton of ore charged. After the greater quantity of the precious metals is electrolytically deposited, the pulp passes over the riffles of a riffle-trough into a leaching tank, the riffles serving to catch any heavy or coarse material, iron pyrites or concentrates. When the leaching tank is filled by the different charges obtained from the charging vat, the supply of ore to the latter is shut off, whereupon the liquid contained in the leaching tank is passed to the charging vat, thence through the tower, and over the riffles back into the leaching tank again, this treatment being continued until tests show that the precious metals have been sufficiently extracted. Practical tests are stated to have shown that from twelve to eighteen hours of electrolyzing and oxidizing are sufficient for leaving the pulp in the leaching tank for about from ten to twelve hours. To regain the precious metals still contained in the liquid, it is finally

proposed to subject it to filtration or decantation, and to heat the liquor thus obtained to 120° or 130° F., and then "subject it to electrolysis in an electrical depositing or precipitation battery, or both, also charged from the dynamo." The pulp, after a second washing for the last trace of precious metal in solution, is run off as waste.

Recovery of Gold and Silver from Cyanide Solutions.—S. B. Christy, Berkeley, Cal. Patent 756,328, April 5, 1904. Application filed May 20, 1901.

The keynote of this process for the electrolytic deposition of gold and silver from very dilute cyanide solutions is the use of a large current density in order to render bulky apparatus unnecessary. The solution, after filtering and clarifying from sediment, is collected in a large storage tank and then circulated through a suitable electrochemical cell and back again to the storage tank rapidly and repeatedly in such a manner that the solution is brought into intimate contact with anodes and cathodes in rapid alternation. The apparatus is shown in Fig. 2. The anodes and cathodes are arranged alternately.

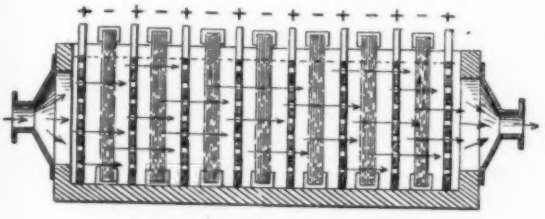


FIG. 2. GOLD PRECIPITATION BOX.

The anodes are pervious to the solution, and may be constructed in the form of wires, rods or gauge, or perforated sheets. The cathodes are also pervious and preferably constructed with a greater precipitating surface than the anodes. No. 24 Birmingham wire gauge iron-wire cloth, 16 meshes per lienar inch, is sufficiently satisfactory, pieces of suitable size being connected electrically in bunches of five or ten by a sheet-iron strip. Instead of iron-wire gauze, metallic filaments or cloth saturated with precipitated silver or gold may be used as cathodes. The velocity of the flow of solution should be such that the potassium cations always find gold solution

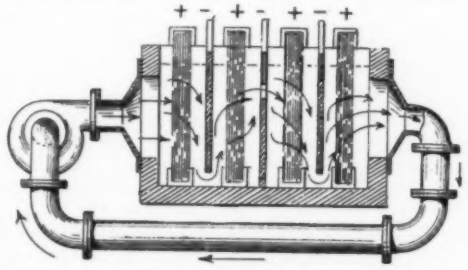


FIG. 3. CLEAN UP BOX.

present to act upon so that gold is deposited without evolution of hydrogen. With a solution containing six ounces silver and gold per ton and voltages of 1.5 to 3.0 volts, a velocity of flow through the precipitation box of one-third of one inch to one inch per second is ordinarily sufficient. A solution is preferably not circulated at a velocity of less than one foot per minute, and the rate of flow is increased in proportion as the gold and silver become exhausted from the solution. It has been possible to precipitate 1000 tons of solution in twenty-four hours in a deposition-box holding only one ton. From 90 to 99 per cent of the precious metals have been recovered, as against 75 or 80 per cent by the old method. The electric current was formerly utilized only to the extent of 5 per cent, and usually not over 1 or 2 per cent, the remainder being wasted, while by the new method the current utilization has gone up to over 80 per cent, with an average ordinarily of from 10 to 20 per cent. The gold and silver deposited by the above method are preferably concentrated in another apparatus, which is shown in Fig. 3. The cyanide solution, which should be as far as possible free from chlorides and sulphates, is forced to flow rapidly through the box E by means of the pump P. The solution passes up and down through the box, and at the same time through the pervious anodes d^3, which are the same electrodes that have previously been used in the precipitation boxes as cathodes, and which carry the deposited precious metals. The sheet iron cathodes are coated with a very thin layer of electroplater's graphite and vaseline before being placed in the box. With an e. m. f. of about ½ volt the gold and silver are rapidly removed from the anodes and deposited on the cathodes, from which they may be pulled off as solid sheets. If zinc precipitation is used instead of electrolytic precipitation, the electric energy is furnished by the zinc in the form of fine granules, shavings or dust. The solution to be treated is forced by a centrifugal pump to circulate from the storage tank through a vessel which contains zinc shavings resting on a filter, and back. The gold and silver are rapidly precipitated by the electrolytic action set up. It is stated that in practice about two ounces of zinc are used to one of gold and silver. The patentee has devoted his attention to the cyanidation process for a number of years, and is well known in connection with the subject.

Apparatus for Electrically Bleaching Materials.—A. A. Vogelsang, Desden, Germany. Patent 756,745, April 5, 1904. Application filed September 21, 1901.

Cotton yarn and other textile materials are bleached in large quantities, from a ton upwards, in such a manner that the material is not moved any more from the time it is placed in the bleaching vat until the bleaching is completed. The complete bleaching plant consists of one tank each for the solutions of salt, sulphuric acid and caustic soda, an electrolyzer, situated so that the salt solution flows to it by gravity, a receiving tank into which the bleach liquor manufactured in the electrolyzer flows, a measuring tank for measuring off definite quantities of liquor, and finally a number of bleaching vats. The bleaching operation is performed by electrolyzing the salt solution in the electrolyzer, a convenient mode of estimating the proper working of the apparatus being to observe the difference of temperature between the inflowing and the outflowing solution, a rise from 12° to 18° C. indicating that the proper strength is attained. The bleach liquor then flows into the receiving tank and is drawn off into the measuring tank ready for use. Meanwhile the material to be treated has been placed in the vats and has been treated with a boiling caustic soda solution, to remove any greasy matters. It is then rinsed with water and the bleach liquor run on, after which the material is rinsed again and scoured with a solution of sulphuric acid, rinsed once more and dried. The electrolyzer belongs to the bipolar type, i. e., to those apparatuses in which only the end electrodes are connected to the source of current, the intervening electrodes being bipolar. The apparatus itself does not present any novel features, but the construction of the electrodes is novel and described in detail. They are illustrated in Fig. 4. The right hand figure shows a cross-section of an intermediate electrode, which is built up of square rods or bars of insulating material, between which

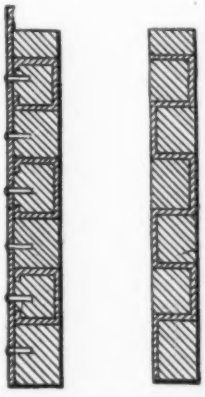


FIG. 4. ELECTRODES FOR BLEACHING PROCESS.

a platinum strip is wound in zig-zag fashion. The end electrode shown at the left-hand is built up similarly, only the current is led to the platinum strips by a lead backing riveted to the insulating bars and extending down one side of the electrode. Several alternative forms of electrodes embodying the same idea are described. To avoid overheating of the electrode, the current density should be about 2 amperes per square millimeter of cross-section, and 50 amperes per square decimeter of electrolyzing surface. The thickness of the platinum foil is greatly exaggerated in the illustrations, as in actual practice foil as thin as 0.03 millimeter may be employed.

Process of Producing Chemical Compound.—John J. Griffin, Washington, D. C. Patent 757,036, April 12, 1904. Application filed January 16, 1902. Renewed September 3, 1902.

The process is based upon the property of metallic carbides to conduct the current like metals and the consequent possibility of utilizing them as electrodes for electrolytic purposes. The gases liberated electrolytically combine with the compounds, which are generated by the chemical action of the above carbides upon the water, and give rise to new chemical products. The electrolytes must be capable of yielding an electrolytic product which will react either on the electrode, solvent, one or both electrodes, or on the product resulting from the direct chemical reaction of the electrolyte on the carbide. As a typical case the electrolysis of dilute sulphuric acid with electrodes of calcium carbide in a diaphragm cell is given. The water of the solution reacts on both electrodes to give acetylene. At the cathode two atoms of hydrogen react on one molecule of acetylene to give ethylene, and four atoms of hydrogen react on one molecule of acetylene to give ethane. The ethylene so produced further reacts on the sulphuric acid in solution to give ethyl sulphuric acid. At the anode two atoms of oxygen react on one molecule of acetylene to give glyoxal, and four atoms of oxygen react on one molecule of acetylene to give oxalic acid. The following is given as a further view of the scope of the invention. Alkaline hyposulphites; ethylene at cathode and thio-glyoxal and other sulphur compounds at anode. Nitric acid and nitrates: ethylene at cathode and cyanic acid and various nitric compounds at anode. Alkaline nitrites and hyponotrites: ethylene and ethane at cathode and cyanic acid and nitro compounds at anode. Hydrochloric, hydrobromic and hydroiodic acids and their salts; ethane, ethylene, and di-iodo-ethane at the cathode, and various halogen addition products of acetylene at the anode. Potassium and sodium hydroxides; ethylene and ethane at the cathode and glyoxal at the anode. Ammonium hydroxide: Alkyl substituted ammonias and cyanides at the cathode and cyanides at the anode. Various addition products in organic solutions are given as follows: Acetic acid and its metallic salts: ethane and ethylene at the cathode and di-methyl-ethylene and tetramethyl-ethane at the anode. Propionic acid and salts: ethylene and ethane at the cathode and ethyl addition products of acetylene at the anode. Higher homologues of the fatty acid series give ethylene and ethane at the cathode and the corresponding alkyl addition products of acetylene at the anode. Salts of aromatic acids give ethylene and ethane at the cathode and aromatic addition products of acetylene at the anode. Aniline and other aromatic bases and their salts give amino and amido substituted ethanes at the cathode and acetylene addition products, corresponding to the anion of the salt used, at the anode. For the production of certain compounds an insoluble substance in a state of fine division may be held in suspension in the electrolyte and may enter into reaction with the electrochemical product. Further details as to the practical carrying out of the various processes are not disclosed in the specification.

Storage Batteries.

Protective Sheath or Envelope for Storage Battery Plates.—Achille Meygret, Paris, France. Patent 756,176, March 29, 1904. Original application filed June 29, 1903. Divided and refiled July 27, 1903.

The plate or grid with the active material on it is covered with a sheath or envelope, in order to prevent the active material from becoming loose and falling down. The protective sheath is obtained by dipping the plate, after the active material has been applied to it, into a bath of castor oil, essence of turpentine, octonitric cellulose, and ordinary nitrate of cellulose of commerce, the tetranitrate of cellulose being preferred. The plate, after having thus received a closely fitting sheath, is then passed between cylinders which cut a series of fine gashes into the sheath, thus allowing the requisite access of electrolyte without destroying the continuity of the protective coating.

Electric Accumulator Plate.—C. P. Elieson, Paris, France. Patent 755,642, March 29, 1904. Application filed October 16, 1903.

The plate described is built up of a number of superimposed thin, flexible strips of lead, which are alternately straight and corrugated. The strips are united at their inner end to guard strips, running along the edge of the plate, while the outer ends are left free. Two of such plates are then placed with their united ends facing each other, and a groove formed on the longitudinal edge of each. A lead tube is then placed in the grooves, and the two sections soldered to the tube. A plate is thus obtained with a hollow rib in the middle, by which means the inventor claims to have in actual manufacture reduced the weight of the plate sometimes as much as 15 per cent.

Process of Making Electric Accumulator Plates.—C. E. Elieson, Paris, France. Patent 755,643, March 29, 1904. Application filed October 16, 1903.

The plate is made by placing alternate straight and corrugated strips of lead with their edges upon a flanged metal tray with guard strips along the longitudinal edges and extending beyond these edges. Similar guard strips are then laid upon the strips and the whole covered by a tray similar to first one. The trays and strips are securely clamped together and the ends of the strips are united by autogenous soldering. A rib of solid metal is thus formed along the two longitudinal sides. The plate is then divided longitudinally in the middle, and the soldered sides turned around to face each other and united by soldering. A plate is thus formed which has a longitudinal rib in the middle, while the strips are free at the edges. Cheap and expeditious production is claimed for such plates.

Storage Battery Grid.—G. W. Frost, Columbus, Ohio. Patent 757,396, April 12, 1904. Application filed February 9, 1904.

The grid of pure lead is shown in Fig. 5; it comprises a frame, a series of retaining strips with a horizontal web, extending to the other face of the plate. The webs taper slightly from the strips to their edges in order to facilitate the removal of the cast grid from the mold. The retaining strips are cast as thin as possible, the usual thickness being 0.06 inch. This thickness is greater than that necessary for rigidity, therefore the cast grids are passed under a milling cutter which removes 0.03 inch from each side of the plate, thereby reducing the thickness of the grid from 0.32 inch to 0.26 inch, and decreasing its weight by one-third. For automobile batteries the grids are cast 0.25 inch thick and milled down to 0.19 inch. Grids

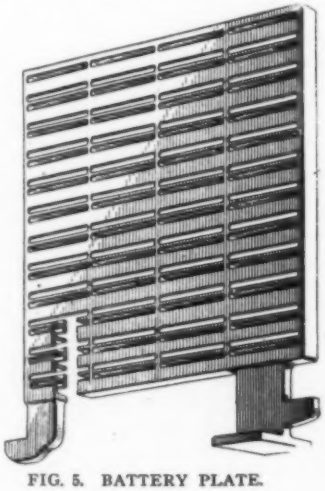


FIG. 5. BATTERY PLATE.

of considerable size are stiffened by ribs. The space available for active material is claimed to amount to from 50 to 70 per cent of the total volume of the electrode.

GALVANIC ELEMENTS.

Battery Cell.—Emerson Whitman, Lynn, Mass. Patent 757,164, April 12, 1904. Application filed July 2, 1903.

A containing vessel of carbon, which serves also as cathode, is corrugated on the inside, and upon the outside glass is applied in a liquid or plastic state, in order to permeate the pores of the carbon, and to prevent leakage of solution through the carbon.

Galvanic Battery.—C. B. Schoenmehl, Waterbury, Conn. Patent 757,355, April 12, 1904. Application filed November 22, 1899.

The cell belongs to the zinc copper oxide type, the essential feature being to provide a receptacle for the copper oxide, widest at the top and narrowing towards the bottom of the containing jar, and to locate the copper oxide in the jar in such a manner that its condition can be always observed.

Dry Battery.—A. F. Swan, Bayonne, N. J., and A. W. Rose, New York. Patent 757,422, April 12, 1904. Application filed July 22, 1903.

The inventors claim the combination of a casing, a negative element and two separate positive elements therein, active material interposed between the negative element and the positive elements, and a switch device and connections whereby the positive elements may be alternately switched into circuit with the negative element, so that each element may be allowed to recuperate while the other is being used. The primary idea has been to get a comparatively large number of cells in the smallest possible space.

ON THE COMBINATION OF A SOLVENT WITH THE IONS.

A highly interesting prelimnary paper by Dr. T. LIVINGSTON R. MORGAN and C. W. KANOLT was presented on April 8, before the New York Section of the American Chemical Society. The following paper will be published in the *Journal of the American Chemical Society* and the *Zeitschrift für Physikalische Chemie*. In the following we give a brief abstract of the paper.

Preliminary experiments show that by electrolyzing a solution of silver nitrate and pyridine in water, that pyridine migrates with the silver and increases in concentration at the cathode, while it decreases at the anode. With cupric nitrate and water, dissolved in alcohol, the water migrates with the copper ions and increases at the cathode and decreases at the anode. This indicates the presence in solutions of combinations of ions with the solvent to form complex ions which break up at the electrodes. The results show only, however, the difference in the amounts of solvent carried by the positive and negative ions.

The application of the law of mass action to one possible equilibrium shows that Van't Hoff's form of Rudolphi's empirical dilution law can be readily derived. Thus, if MA is the salt, and S the solvent, we have

$$2MA + (x + 2y + z)S = (M_2.xS)^{+ +} + 2(A.yS)^{-} + zS$$

and if Cs is the undissociated concentration; Ci that of one of the ions and z large compared to x and y, it follows that

$$\frac{Ci(2Ci)^2}{Cs^2} = 4\frac{Ci^3}{Cs^2} = \text{constant}.$$

The authors call attention to the fact that in this way it is easy to account for the variation in the speed of migration of the ions with the dilution; the presence of solvent of crystallization, and the variation in the value of n in the general empirical dilution law $\frac{Ci^n}{Cs} = \text{constant}$. It is observed that this takes nothing away from the ionic theory, but, in fact, conditions only those portions of that theory which have hitherto failed to hold.

Correspondence.

ELECTROLYTIC AND ZINC PRECIPITATION OF GOLD FROM CYANIDE SOLUTIONS.

TO THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

Sir—With regard to the article on electrometallurgy in gold, published in the February issue of ELECTROCHEMICAL INDUSTRY, I may say that there is a great deal of interest in the development of this process since I left South Africa, and that it is now an up-to-date process in every sense. The electrolytic and the zinc processes are combined together and now used in our best plants, the electrolytic process being used to clean the solution and taking out from 90 to 93 or 94 per cent of all the products and abstracting practically all of the copper. About 8 or 9 per cent of the electric box capacity is filled with zinc, to which the electric current is also added. This is used for taking out the last few per cents of gold and silver. At our works in Salvador we make an extraction of about 99 per cent of the values in the solution on regular monthly runs, and by this combination the zinc is constantly at its best, as everything that would spoil the surface of the zinc as a precipitating surface has been eliminated by going through the electrolytic precipitation first.

At present we run the electrolytic process in three plants in this country; Virginia City, Minas Prietas, in Mexico and at Butters Salvador Mines in Salvador. All these plants have introduced small zinc additions electrically connected with the precipitation boxes. This gives us a very complete precipitation process.

CHARLES BUTTERS.

San Francisco, Cal.

FERRO-NICKEL FROM PYRRHOTITE.

TO THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

Sir—On page 154 in the April issue of the ELECTROCHEMICAL INDUSTRY there appears a synopsis of my article in the *Iron Age* of February 18, on "Ferronickel Direct from Pyrrhotite," and the attention is directed to a misprint, which I hereby wish to correct, namely, regarding the power used in the experiments referred to, the same being 1350 amperes and 80 volts, instead of the 135 amperes and 80 volts given.

ERNST A. SJÖSTEDT.

Sault Ste. Marie, Ont.

ARSENIC IN COPPER REFINING.

TO THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

Sir—In the April issue of your paper I note that Mr. L. Webster Wickes makes, in reference to a paper of mine about the sliming of arsenic oxide in "metallic electrolytic dissolution," certain statements which call for some explanation on my part.

The cases stated by Mr. Wickes are, of course, entirely different from the commercial electrolysis of copper or nickel where the percentage of arsenic has been reduced to a very small limit by the ordinary fire metallurgical methods. There is, however, not much doubt to my mind that the oxides of arsenic, antimony, etc., present in the anodes, pass into the slimes directly, but are slowly dissolved from the slimes by purely chemical action. This redissolution will occur even in an electrolyte very near the neutral point.

Naturally the fact that arsenic is more electropositive than copper, and that its cations are present in such small numbers in comparison with the copper cations makes it clear that provided the proper electrode-voltage is not exceeded, arsenic is

codeposited with copper in only infinitesimal amounts. This explains satisfactorily the facts given in the last two paragraphs of Mr. Wickes' article, and also brings out the point raised by me on several occasions, namely, the importance of knowing the sliming effects of different metalloids present in a metallic anode as conditioned upon the various physical, chemical and electrochemical states.

Woolsey McA. Johnson.

La Harpe, Kansas.

Book Reviews.

Electrolytic Preparations, exercises for use in the laboratory by chemists and electrochemists: by Dr. Karl Elbs. Translated from the German by R. S. Hutton, M. Sc. New York: Longmans, Green & Co. 12 mo., 100 pages. Price $1.60.

Our friend, the translator, lecturer on electro-chemistry at Owens College, Manchester, England, is doing yeoman's work for the cause of electrochemistry in many directions, but has done no one thing of more use to English-speaking students than the translating of Dr. Elbs' laboratory guide. Professor Elbs is well known as a prominent representative of modern electrochemistry in Germany, and has been successful both in original research work and as a teacher. An outcome of his activity as university teacher is his laboratory guide. The only shortcoming of the book is its brevity, for after perusing the twenty-nine pages devoted to inorganic preparations, and noting the fifty pages following dealing with organic compounds, the conviction is strong upon us that there is not only room, but a crying need for such an enlargement of the work as would furnish a full 100 pages to each of these departments. As it is, the experiments in inorganic chemistry are certainly too few, and, if measurements of current output are made, are too fragmentary to illustrate all of the fundamental laws of electrolysis and consequent formation of chemical compounds. Brevity is, after all, one of the least blameworthy, and most easily remedied, shortcomings for which an author can be criticised.

CARBON BRUSHES FOR DYNAMOS.

That the use of carbon brushes (instead of the metallic brushes which were first exclusively used) has greatly simplified the solution of one of the most important problems in dynamo design—namely, to insure good commutation—is a fact now fully recognized by all electrical engineers. It is also recognized that in order to obtain the best results, a kind of carbon should be used which is specially adapted to the particular conditions in each case. In view of the very powerful currents generally used in electrolytic works, good commutation is a matter of great importance in such works.

The brush made by the Le Valley Vitæ Carbon Brush Co. was the first introduced on the market as a permanently self-lubricating brush; it requires no attention, since it constantly lubricates the commutator without gumming. On account of the quality of carbon used for this brush, the following special features are claimed for it. It throws off no carbon dust, thus obviating one of the prime causes of short-circuiting, particularly on enclosed motors. It does not cut or scratch the commutator, so that no sandpapering or turning down is required; the brush, therefore, has itself a long life, and also lengthens the life of the commutator. It has a much lower resistance and gives better contact than ordinary carbon; it is claimed to carry at least 100 per cent more load than brushes made of ordinary carbon.

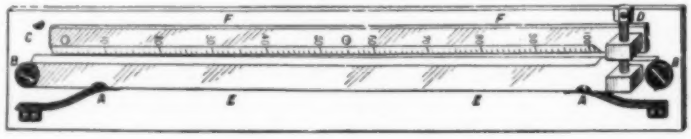
Different grades of carbon are used according to the special conditions under which the machine has to work—especially whether the brushes are to be used on a stationary machine or on railway car motors. For ordinary use three different grades are made, being designated as hard, medium, and soft, while for heavily overloaded machines, sudden and extreme change in load, and for hot commutators, as well as for special traction service, special grades of carbon are furnished. The Vitæ carbon brushes are furnished in all the various sizes needed in practice, and the Vitæ generator brush material, regular or special grade, can be had in plates 13 x 9 inches, of any thickness, or strips 12 inches long and of any width up to 4 inches, and of any thickness. These plates, or strips, can be cut with an ordinary hack-saw or emery wheel, to any size required.

THE MEASUREMENT OF GOLD AND SILVER BUTTONS IN QUANTITATIVE BLOWPIPE ANALYSIS.

The quantitative blowpipe assay for gold and silver was invented by Harcourt, a student of Freiberg, in 1824. Instead of weighing the very small buttons obtained he measured their size on a scale which he had constructed empirically by drawing two fine slightly deferring lines on white cardboard and placing buttons of known gold or silver content between the lines at points where they fitted, and marking opposite those points the corresponding content of the ore. The method was further developed by Prof. Plattner, who constructed the well-known button scale ruled on ivory. To fix the dimensions of the scale, he assayed very rich silver ore repeatedly in the muffle until it was known with certainty to contain exactly 3.4 per cent of silver. He then made repeated blowpipe assays of this ore, obtaining buttons very close together in size and weight. Two lines were then drawn on ivory, so that they deferred approximately the diameter of these buttons in a length of 150 mm. The scale was then divided into equal divisions, and the silver content corresponding to each division calculated on the assumption that the buttons are nearly spheres, so that their weights vary as the cubes of their respective horizontal diameters.

Prof. V. Goldschmidt, of Heidelberg, later proposed two improvements, the first being to remelt the cupelled buttons on charcoal, and the second to measure the horizontal diameter of such remelted buttons under the microscope. The diameter being determined, reference to a previously constructed table, the design of which is based on an ingenious plan, gives the volume and weight of the button, when of gold or silver.

Dr. J. W. Richards, of Bethlehem, Pa., has adopted Goldschmidt's idea of remelting the button on charcoal wherever practicable, but has devised a modification of Harcourt's method for measuring the buttons. His method is described by him in a paper, published in the Journal of the American Chemical Society, vol. 23, No. 4, April, 1901, page 203. In this paper a concise and complete review of the different methods available to the blowpipe assayer is given, and the reader, interested in the subject, may be referred to it. In the following we give a description of Dr. Richards' scale.

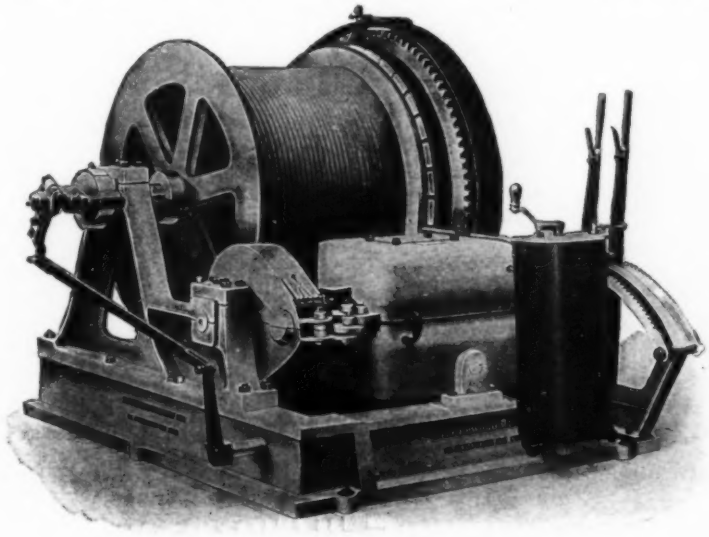


The idea is to make two metallic edges perfectly straight, lying on a flat surface and held apart at the other extremity by a set screw, so that the point 100 may indicate a fixed width or separation of almost exactly 1 mm. In reality the button whose horizontal diameter fits at 100, has a diameter of 1.02 mm., but this distance has been so chosen that the volume, and, consequently, the weight of said button are exactly that of a perfect sphere whose diameter is 1 mm. The other numbers

on the scale have the same significance. For example, the button whose horizontal diameter fits at 43.5, has the volume and weight of a sphere whose diameter is 43.5 hundredths of a millimeter and such is the basis on which the table is calculated.

In using the scale the button is put into the groove, the scale inclined slightly, and tapped until the button wedges itself. The tenths of a division are estimated, taking the points where the sides of the button touch the scale as the reading. As the button may sometimes roll with its shorter vertical diameter across this scale, several readings are taken, and the highest reading, occurring with regularity is the true horizontal diameter. For instance, among 43.4, 43.4, 41.6, 43.5, 41.8 and 43.5 it is evident that 43.5 is the horizontal diameter and the 41.6 or 41.8 the vertical. The button can also be observed under the lens to see how it is lying at any given reading

A gentle spring keeps the right-hand strip against the set screw, thus allowing it to be pressed back for cleaning out the slot with a brush or removing a button. The scale is made of hardened aluminium for lightness, and is set in a velvet-lined leather case. It is made by Messrs. Williams, Brown & Earle, of Philadelphia.



ELECTRIC MINING HOIST.

DIRECT CURRENT ELECTRIC MINING HOIST.

Mine superintendents and metallurgical engineers generally will be interested in the electric hoists illustrated in the adjoining engraving, which shows the latest pattern of a direct-current electric mining hoist, with patent friction drum and brake, built by the Lidgerwood Manufacturing Company, 96 Liberty Street, New York City. This hoist is designed for use with direct current of 500 or 250 volts, and embodies in its construction the various features which are characteristic of all Lidgerwood hoists, and which have gained them wide acknowledgment as the standard type of modern high-speed hoisting engine.

Briefly, there is the usual pleasing simplicity in design with few parts, and compactness in construction, giving great strength and insuring the highest efficiency and durability in service. The drum motor and controller are mounted complete on a bed-plate. The resistance boxes are usually separate from the hoist, being conveniently located so that the heat generated may not be annoying to the operator. In smaller sizes it is sometimes desired to have the machine completely self-contained and portable, in which case the resistances are of special form, and attached to the inside of the bed-plate.

The friction drum is of the standard Lidgerwood form, equipped with all the latest patented improvements. The motor, which is made by the General Electric Company, is of the armored type and especially adapted for hoisting purposes. All the moving parts are protected from dust and moisture by suitable casing, and the gearing from the motor to intermediate shaft is cut, and enclosed in an oil-tight gear case.

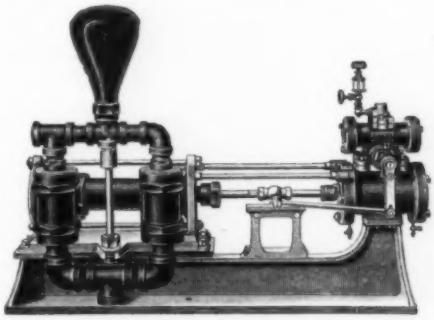
The drum gearing is cast from standard patterns and is protected by means of the usual guard band. The controller, which is of the railway type, is provided with a reversing switch, and mounted so as to be most convenient to the operator.

The friction and brake levers are mounted in a rack with notched quadrants and are fitted with thumb-latches. A large number of these electric mining hoists have been built, and have given, in every instance, complete satisfaction.

ACID PUMPS.

One of the greatest difficulties met with by the manufacturers of acids is the destructive action of the liquids upon the metal piping and pumps of their plants. This has been overcome by the substitution of hard rubber, of which not alone pipings and fittings, but pumps and all kinds of utensils are now successfully made, for conveying acids, chemicals, dyes, brine, etc.

The leading chemical manufacturers and dye works of this country have been quick to recognize the advantages of this material and to adopt it for their use. It is manufactured by the American Hard Rubber Co., an illustration of a hard rubber pump being given in the adjoining figure. The American Hard Rubber Co. is exhibiting their products at the St. Louis Exposition, Liberal Arts Building, aisles 7-H and invite inspection of their pumps operated by hand, steam or electricity.



HARD RUBBER PUMP.

UNION ENGINEERING BUILDING.—In order to enable the American Society of Mechanical Engineers, and the American Institutes of Electrical Engineers and of Mining Engineers, to avail themselves of Mr. Carnegie's gift of a building for headquarters and library purposes, etc., the conference committee has had drafted a bill incorporating what is known as the United Engineering Society to hold the property for the societies. This bill was introduced in the State Senate by Senator Townsend, of Utica, and has already passed both the chambers, and has gone to the Governor for signature. The bill is virtually a transcription of the act incorporating the Cooper Union.

INDUSTRIAL NOTES

We have received from the Whitall Tatum Co., of Philadelphia and New York, their 1904 price list of chemists' glassware and sundries. Besides their regular qualities of flint and green glass, they make amber blue, dark green and white opaque glass.

Messrs. Richard C. Remmey & Son, the well-known chemical stoneware manufacturers, of Philadelphia, announce that they have admitted Mr. John B. Remmey as a partner, and that their business will be continued in future as Richard C. Remmey & Sons.

We have received from Messrs. Merck & Co. of New York, their little pamphlet with the title "Merck's Reagents," conforming to the standard laid down in Dr. Krauch's "Testing of Chemical Reagents." The pamphlet contains a concise list of the different reagents and their uses.

The Westinghouse Machine Company, of Pittsburgh, has just issued an interesting and neatly illustrated pamphlet on the Westinghouse-Parsons Steam Turbine. In view of the importance of any new advances made in the generation of power for electrochemical and metallurgical works, we will return to this subject in a later issue.

Refractory Brick.—The Harbinson-Walker Co., of Pittsburgh, has issued a catalogue containing a large amount of very useful information in connection with the use of silica, magnesia, chrome and fire-clay brick and various refractories, with other tables of use for metallurgists. The illustrations and furnace drawings are very neat, and print and mechanical make-up are excellent. The catalogue is bound in red morocco.

Platinum.—Platinum and its allied metals, which depend almost entirely upon the Ural Mountains for their crude supply, have already felt very decided results of the Russian-Japanese war, owing to heavy withdrawals of forces from this mountain district by the Russian Government, the effect of which has naturally caused an advance in current rates. For some time there has been an increasing demand for platinum and its alloys in the electrical and chemical fields, which is constantly being supplemented by the increasing use of gas engines, automobiles, and various new electrical appliances, having platinum contacts and attachments. This growing demand, with doubtless a long continuance of the present situation in Russia, would strongly point to a further advance in a very short time.

PERSONAL.

Mr. Frank Kleetko, the well-known copper expert and consulting engineer, announces the removal of his offices to 307 Battery Park Building, 24 State Street, New York.

Wilhelm Hittorf, Professor of Physics and Chemistry in Muenster, Germany, celebrated his eightieth birthday on March 27. He has especially distinguished himself by his very careful and extended investigations of the transport numbers of the ions in aqueous solutions. These researches were begun by him in 1853, but the importance of his investigations were not recognized before the end of the seventies.

DIGEST OF U. S. PATENTS

Prior to July, 1902.

Compiled by Byrnes & Townsend,
Patent Lawyers,
National Union Building, Washington, D. C.

Chemicals.

The following patent should be inserted on page 124, March issue, where it had been omitted by mistake.

700,671. May 20, 1902. Max Buchner, Mannheim, Germany. Reduces azo compounds dissolved or suspended in an electrolyte in the presence of tin.

Example 1.—Reduction of para-amido-azo-benzol to paraphenylenediamine. Anode.

Anode, lead. Anode solution, 10 per cent sulphuric acid. Cathode solution, "a mixture consisting of 48.7 parts, by weight, of chloride of para-amido-azo-benzol, five grams of powdered electrolytically-precipitated tin dissolved or suspended in one hundred parts, by volume, of water, and two hundred and fifty parts, by volume, of fuming hydrochloric acid." Current density 300 to 400 amperes per square meter. Temperature, 60° C. "The resulting paraphenylenediamine is precipitated in the form of a chloride by saturating the cathode electrolyte with hydrochloric-acid gas in the cold, the anilin, which is produced at the same time, remaining in solution.

Example 2.—Reduction of orange II. to amido-beta-naphtol.

Anode solution, 10 per cent sulphuric acid. Cathode solution, thirty-two parts of orange II., two hundred and fifty parts of water, and two hundred and fifty parts of fuming hydrochloric acid.

The Production of Aluminum from Molten Electrolytes.

(Continued from Page 166.)

476,914. June 14, 1892. Myrthil Bernard and Ernest Bernard, Paris, France.

Electrolyzes a molten mixture of cryolite and sodium chloride, in proportions giving a bath which is lighter than aluminium, *e. g.*, aluminium fluoride, 35 parts, sodium fluoride, 10 parts, and sodium chloride, 55 parts. To produce pure aluminium: The vessel consists of metal set in fire-brick. The anode and cathode are vertical carbon rods, the cathode resting below in a small crucible of cast alumina or calcium fluoride, placed on a cast plate of the same material, which rests on the bottom of the vessel. A high resistance shunt from the cathode terminal to the vessel makes the latter a supplementary cathode, from 5 to 10 per cent of the current passing from the anode to the vessel and coating its wall with a thin protecting lining of an aluminium alloy. The pure aluminium deposited on the cathode rod runs down into the crucible. To produce alloys: Employs a cathode vessel of the alloying metal, having an inclined bottom with tap-hole, set in fire-brick. The aluminium deposited on the vessel forms a fusible alloy therewith which melts and runs down to the tap-hole. May increase the percentage of the alloying metal by using an anode of this metal instead of one of carbon.

503,929, August 22, 1893, Joseph B. Hall, Wheeling, W. Va.

Electrolyzes alumina dissolved in a fused mixture of aluminium chloride, sodium chloride and lithium chloride. May supply alumina by using an anode of mixed carbon and alumina, or may feed the alumina in, stirring it mechanically. Cathode vessel of carbon or mixed carbon and alumina, encased in iron. To produce aluminium bronze, maintains a layer of molten copper in the bottom of the vessel.

512,801, January 16, 1894, Willard E. Case, Auburn, N. Y.

Combines solutions of commercial aluminium sulphate and calcium fluoride to form an "aluminium fluor-sulphate solution." Adds ammonia or fixed caustic alkali to precipitate any iron present as an impurity, removes the iron and adds more caustic to precipitate the desired white aluminium compound, which is removed, fused and electrolyzed, preferably with an initial addition of cryolite to increase fusibility.

512,802, January 16, 1894, Willard E. Case, Auburn, N. Y.

Adds calcium fluoride to a solution of crude aluminium sulphate to form an "aluminium fluor-sulphate solution." Adds an alkali carbonate, e. g., sodium carbonate, to precipitate any iron present as an impurity, removes the iron and adds more carbonate to precipitate the desired white aluminium compound, which is removed, fused, preferably with an addition of cryolite as a flux, and electrolyzed.